# THE PRINCIPLES
# OF FACTORY ORGANIZATION
# AND MANAGEMENT

# THE PRINCIPLES OF
# FACTORY ORGANIZATION
# AND
# MANAGEMENT

By

RALPH CURRIER DAVIS, M.E., M.A.

HARPER & BROTHERS, PUBLISHERS

NEW YORK AND LONDON

MCMXXVIII

THE PRINCIPLES
OF FACTORY ORGANIZATION
AND MANAGEMENT

Printed in the U. S. A.

---

*First Edition*

E-C

TO

MY WIFE

# PREFACE

IN WRITING this book, the author has had in mind the difficulties which confront the student of industrial management or the junior executive who aspires to greater responsibilities, when he attempts to obtain a broader and more complete understanding of the fundamentals and the work of factory management. Accordingly, an effort has been made to draw a clear picture of the fundamental functions and principles of factory organization and management and their relations to one another. It was felt that while the character and extent of their development may vary, most factory organizations perform essentially the same fundamental functions. While the character and manner of their application may vary, the fundamental principles of factory management, to a large extent, are universal in their application. A thorough understanding of these principles and functions is prerequisite to progress in the field of factory management.

The author's experiences in teaching the subject has led him to feel that one of the greatest obstacles to the student's acquiring a thorough understanding of the fundamentals of the subject is his difficulty in visualizing the problems of management, due to his lack of background. Therefore, the book has been generously illustrated throughout.

The management problems in one plant are never exactly the same as in another, even in the same industry. Such differences are inevitable because of differences in plant, personnel, equipment, product, location, and other factors. While the principles involved, and to a large extent the method of attack, may be the same, the solution may be quite different. To a considerable degree, therefore, routines are peculiar to the particular plant. Accordingly, those routines which are described are intended merely to illustrate and emphasize the principles being discussed. For the most part, they are taken from the practice of medium-sized or large plants. While the same functions may be present in the small plant, usually it is necessary to combine them in the interests of economy. Consequently, it is less easy to study their performance.

While it is intended primarily for the elementary student of the subject, it is hoped that the book will find favor in the eyes of experienced executives in so far as it records some of the more advanced management practices and the more important trends in modern management.

In reading many books dealing primarily with factory management, the author has noted a tendency to indulge in discussions of subjects primarily in the fields of distribution or finance. Except where it has been necessary to make clear the relations of certain problems in these fields to the work of factory management, the author has consciously restricted himself to a discussion of those subjects which may properly be considered to come within the field indicated by the title of this book. No criticism of such books is implied. It is recognized that such broad treatment may be necessary in some cases.

It is hoped that along with other good books in the field, this book may aid in stimulating an interest in the application of more exact methods to the problems of factory organization and management, to the end that more accurate solutions, equitable in their relations to the interests of the employer, employee, and the public, may result.

It is desired to acknowledge the helpful criticisms of Professors M. B. Hammond, and Willis Wissler of the Ohio State University, and Mr. John A. Fisher, Consultant in Management. In adddition, it is desired to acknowledge the contributions of valuable illustrative material by the following concerns: The Kearney & Trecker Co.; Lockwood, Greene & Co.; The Austin Company; The Jones & Lamson Machine Co.; The National Lamp Works; The Goodyear Tire and Rubber Co.; The Perfection Stove Company; Remington Rand, Inc.; The Winchester Repeating Arms Co.; The C. & G. Cooper Co.; The Brown & Sharpe Manufacturing Co.; The Thompson & Lichtner Co.; Dwight V. Merrick, Time Study Consultant; The Westinghouse Electric and Manufacturing Co.; The White Motor Company; The Robbins & Myers Co.; The Pure Oil Co.; The Procter & Gamble Co.; The Seiberling Rubber Co.; The White Sewing Machine Corporation; The Berger Manufacturing Co.; The Durand Steel Locker Co.; The Harnischfeger Corporation; Manning, Maxwell & Moore; The Niles, Bement, Pond Co.; The C. O. Bartlett & Snow Co.; The Chain Belt Company; The Lamson Company; The Yale & Towne Manufacturing Co.; The Elwell-Parker Electric Company; The Stuebing, Cowan Co.; The Clark Tructractor Co.; The Plimpton Lift Truck Corporation; The Cleveland Crane and Engineering Co.; The Nash Motors Co.; The Van Dorn Iron Works; The Warner & Swasey Company; The United States Steel Corporation; The Scott Company; The National Cash Register Company.

RALPH CURRIER DAVIS.

COLUMBUS, OHIO

Nov. 15, 1927.

# CONTENTS

# DIAGRAMS

# PLATES

THE PRINCIPLES
OF FACTORY ORGANIZATION
AND MANAGEMENT

# THE PRINCIPLES OF FACTORY ORGANIZATION AND MANAGEMENT

## CHAPTER I

## THE DEVELOPMENT OF MODERN MANAGEMENT

**The Economic Development of Man.** The progress of man to his present state of civilization was relatively slow until the nineteenth century. Prior to this time power had not been applied to the production of goods. Efficient organizations and methods for production were not developed until long after machinery had been widely introduced. It is our purpose to examine these relatively new organizations and methods in order to learn something of their operation and the principles on which they are based. In order to do so intelligently, it is necessary to review briefly some of the economic developments which have led up to them. During his development, man has passed through certain general economic stages. In the hunting and fishing stage, he lived almost entirely on the bounties of nature. His food consisted of the meat of wild animals, fish, fruits, and vegetables. His garments were animal skins. There was no production as we understand the term today, and practically no accumulations of economic goods.

In the pastoral stage, he had learned to domesticate and breed certain of the wild animals which he formerly hunted. By so doing he had introduced a primitive form of production and made his food supply more certain. The natural increase of his flocks resulted in the accumulation of a form of wealth, which made possible greater leisure for the more influential or gifted members of the primitive, tribal community. This partial freedom from the work of satisfying physical necessities is a prerequisite to the development of the arts and sciences, and in turn to the development of better production methods.

In the agricultural stage, man had learned to cultivate certain of the wild grains. Once more he had advanced his economic state as he had further stabilized his food supply, increased his ability to produce the necessities of life, and furthered the accumulation of wealth. With

this advance came greater leisure for a greater number. As compared with the life of the modern worker, however, the life of most people was extremely hard. Until approximately the eighteenth century, people lived largely under agricultural economy. In the Middle Ages, production was largely agricultural, and exchange consisted chiefly of the barter of agricultural products. There was comparatively little trade between cities and less between countries.

The last stage of man's economic development is the industrial stage, which is characterized by the widespread use of machinery, greatly increased per capita production, the use of large aggregations of capital, mass production, a minute division of labor, intricate machinery for the exchange of goods, and many other social and economic phenomena. There has been no sharp dividing line between the various stages in the economic development of man through the ages. Examples of all of them may be found in various parts of the world today.

**The Beginnings of the Industrial Stage.** Under the feudal system of government, predominant in Europe from the ninth to the fourteenth century, agricultural economy predominated. The family was a self-supporting unit. It raised its own food supply, spun the material for its clothing, and supplied itself with simple necessities. Any surplus of agricultural production usually went to the feudal lord. For the great masses of the population there was little opportunity for the accumulation of wealth and relatively little leisure. The development of the mechanical arts proceeded slowly and was, for the most part, in the hands of itinerant craftsmen.

Gradually, various free cities became established throughout Europe. They enjoyed a large measure of self-government, although, in most instances, they owed allegiance to some feudal lord. Freedmen and craftsmen of various kinds gravitated to these cities. Under the more favorable conditions which obtained, the arts and crafts were developed to an extent not previously known. Many cities became noted for their development of certain crafts. For example, Sheffield, England, became noted for its steel. The growth of the free cities marked the beginning of the separation of a considerable portion of the population from the soil.

These developments led up to the handicraft period. Under the more primitive agricultural systems, craftsmen were largely itinerant. They performed their work at the homes of their customers, using the materials furnished by them. They owned their few simple tools. As the handicraft period developed in the cities, the master craftsman gradually began to perform his work in his home or shop, using his own materials or those brought to him by his customers.

The growth of the guild system was a parallel development. With

the growth of the free cities in England, many powers of government were delegated to their governing bodies by the feudal overlord. The power to regulate quality, prices, the wages of journeymen, and similar powers were originally reserved to the state. With the growth of the cities the duties of government became so onerous, that the power to regulate the crafts was delegated gradually to the guilds. To some degree, therefore, they were representatives of the state in these matters.

The guilds cannot be compared closely with the present-day labor unions. They were vertical combinations, including all engaged in the craft, from the master down to the apprentice. The master was more like the owner and manager of a business than he was like the modern workman. The modern trade union is a horizontal combination of workers, tending to draw a sharp dividing line between those who own and manage and those who merely sell their labor for wages.

Under the guilds, a hard and difficult apprentice system was developed. Laws were enacted for the control of the system. The wages and conditions under which the journeymen worked were very poor. Efforts on the part of journeymen to better their condition were suppressed on the theory that they constituted conspiracies against the state. For the most part, however, the journeymen and apprentices worked in harmony with the masters. For one reason, it was comparatively easy to become a master after serving an apprenticeship. No great accumulation of capital was required before one could set up in business as a master. The guilds flourished from the twelfth to the fifteenth century. They declined during the sixteenth and seventeenth centuries, due partially to the gradual imposition of restrictions making it increasingly difficult to become a master and the results of widening markets.

Toward the end of the guild period the masters distributed work to journeymen, who performed it in their homes, under the supervision of the master. This system, generally referred to as the cottage stage of production, developed during the fifteenth and sixteenth centuries. Gradually, masters began to assemble numbers of journeymen in one building. Work was collected by the master, performed by the journeymen, and distributed by the master, who collected payment. The assembling of a relatively large number of journeymen under one roof enabled the master to handle more business, gain greater efficiency, through some primitive division of labor, and greater profit. It tended to divorce the master from the work and led directly into the factory system.

During the middle of the eighteenth century a number of inventions were developed in England, within a comparatively few years,

which resulted in the Industrial Revolution. In 1765, Watt perfected the steam engine. By this development the application of steam power to the production of goods was made practical. However, the steam engine was not introduced into industry until the latter part of the century. In 1770, Hargreave's spinning jenny was invented, which resulted in the saving of much hand labor in the spinning of yarn. In 1771, Arkwright applied water power in a spinning device called the water frame. In 1779, Crompton's "mule" spinner was developed, embodying the features of both previous inventions. Cartwright's power loom for the weaving of cloth was invented in 1785. These inventions had far-reaching effects and probably marked the beginnings of the modern factory system, although primitive factories using simple hand devices were in existence prior to this time.

The Industrial Revolution was characterized by two great changes—the transfer of skill from the worker to the machine, and his loss of control of the tools of production. The resulting sudden and great increase in production per employee caused great unemployment and suffering in the textile industry. The transfer of skill to the machines rapidly eliminated many trades that had been learned by hard and long apprenticeships. Widespread opposition to the introduction of these inventions developed. In some of the textile centers the workers invaded the factories and wrecked the machines. These inventions represented real progress in the art of textile production that could not be stopped by violence, and gradually the old hand methods were displaced. The deplorable conditions which developed from the change probably have been a factor which has negatively influenced the mind of the English worker regarding the introduction of devices and methods designed to increase individual output and to transfer hand skill to machines. Today it is widely realized that such developments lower the costs of goods, broaden markets, and eventually result in greater employment, with better standards of living.

With the widespread introduction of machinery, the capital requirements of a new enterprise were greatly increased. The opportunity for a journeyman to engage in business on his own account was correspondingly diminished. He gradually lost control of the tools of production. This development hastened the separation of those who own and manage and those who operate.

**The Development of Industry in America.** The English Colonies in America did not pass through the early stages of economic development, but for the most part commenced at the handicraft stage, which had been reached in England. Isolated communities, remote from the coast. were exceptions to this. The Revolutionary War took place during the period of the Industrial Revolution. The development of

the factory system in the United States began after the war. The first textile factory in the United States was established in 1790.

An important development which began in early Colonial times and continued rapidly until the close of the nineteenth century was the widening of markets. Even with the development of the great cities of England and Europe, trade was conducted chiefly within the territories immediately contiguous to them, for many centuries. With the conditions of production controlled by the guilds, competition was conducted on a quality rather than a price basis. One of the great functions of the guilds was the regulation of quality. Under such a system, labor costs are not an important competitive factor. As markets widen and goods are distributed over an increasing area, large producing centers are brought into competition with one another. It becomes more and more difficult for local organizations to enforce price and quality regulations. The price factor in competition increases in importance. Wages, as a factor in the cost of production, are forced on the attention of the masters. The temptation to reduce wages is introduced. There appears a widening breach between the interests of employers and employees. Toward the close of the eighteenth century, gradually-rising living costs resulted in numerous efforts by journeymen to better their condition. Their efforts were opposed by employers and others interested in fostering England's growing foreign trade. Parliament was flooded with petitions to suppress these so-called conspiracies of journeymen. As a result, by 1812, most of the early laws designed to regulate and protect the condition of the apprentices and journeymen had been wiped out.

In America the widening of markets began with the development of coastwise trade in the Colonies. It continued with the development of post roads and the use of inland waterways. It was greatly accelerated by the development of canals between 1817 and 1837, the building of railroads which began about 1830, and the invention of the telegraph in 1844, which greatly facilitated communication between various centers.

As the conditions of production and distribution became more complex, a tendency to specialize developed, which led to the development of the manufacturer, wholesaler, retailer, consumer method of production and distribution. It has made it more difficult for the manufacturer to control the conditions under which he produces.

With the growth of industry and commerce, it is necessary that large sums of money be advanced before the processes of production and distribution can be performed. Advances to labor in one form or another must be made long before products can be exchanged. In the United States the growth of strong financial groups and sound

financial methods paralleled the growth of industry and commerce. Today, the banking function occupies a vital position in the economic structure.

The development of the factory system both here and abroad has resulted in an increasing division of labor. In the handicraft period, the craftsman performed all of the operations in the production of his wares. He developed great hand skill and pride in workmanship. Today, much of this hand skill has been transferred to machines. To a large extent, these machines also have been specialized and perform but one or two operations in the manufacture of the product. As a result, the modern workman may perform, day after day, only a few simple hand movements that require a minimum of thought. He may have little knowledge of the relation of his work to the other processes. As a result, his interest is not in his product, but in seeing how much wage he can get for the least effort. However, the advantages of the division of labor are greater than its disadvantages. If the workman performs only one or two operations on the product, he acquires by repetition greater skill in their performance than he would if he produced the complete product. The quantity and quality of his production are increased. He can be trained to perform these simple operations satisfactorily in a much shorter time than he could be trained to produce a complete product. The transfer of hand skill to machinery is facilitated, resulting in further increases in production. For these reasons, the division of labor has become an important factor in social and economic life.

These tendencies developed slowly up to the time of the Civil War. The factories which existed were comparatively small. They were dominated by the owner, who, in many instances, worked at a bench beside his employees. There was often a close personal relationship between them. The probability that serious grievances would receive adequate consideration was greater than in large modern factories with their more impersonal relationships. Probably these more personal relationships did much to counteract the effects of those economic forces, tending to widen the breach between the employer's and employee's interests, which have been previously noted. Professor Groat[1] states that the first real strike in the United States occurred in 1741. Nevertheless, there are relatively few instances of serious industrial strife until after the Civil War.

**Developments Following the Civil War.** Following the Civil War, the United States experienced a great industrial expansion. The means of communication and the exchange of goods were rapidly developed. During the 'seventies and 'eighties the use of the telegraph

[1] *Organized Labor in America*, by Groat, p. 163.

was extended and railroad building was carried on in the West at such a pace that it became one of the important causes of the crisis of 1883. A flood of immigration bringing cheap labor to the United States was an important factor in the expansion. It caused considerable change in the conditions of labor and a reallocation of work to various labor groups.

The interchangeable system of manufacturing, originated in 1798 by Eli Whitney in connection with the manufacture of guns, was further developed and greatly extended. Under this system, limits of variation from the engineering dimensions are established for each part. Holding devices are designed to hold the work in the correct position for proper processing by the tool. The machine is adjusted and the tool is designed and set up in such a manner that the part is processed within the limits of variation for the particular operation. As shown in Plate 1, the workman has only to start the machine and place the pieces in the fixture. The machine then performs the operation correctly. Under such conditions, there has been not only a transfer of skill to the machine, but also a considerable transfer of thought. While the interchangeable-parts system tends to extend the division of labor and the automatism of work, to the detriment of the employee's creative individuality, it also has distinct benefits. In the long run, these benefits are the more important consideration.

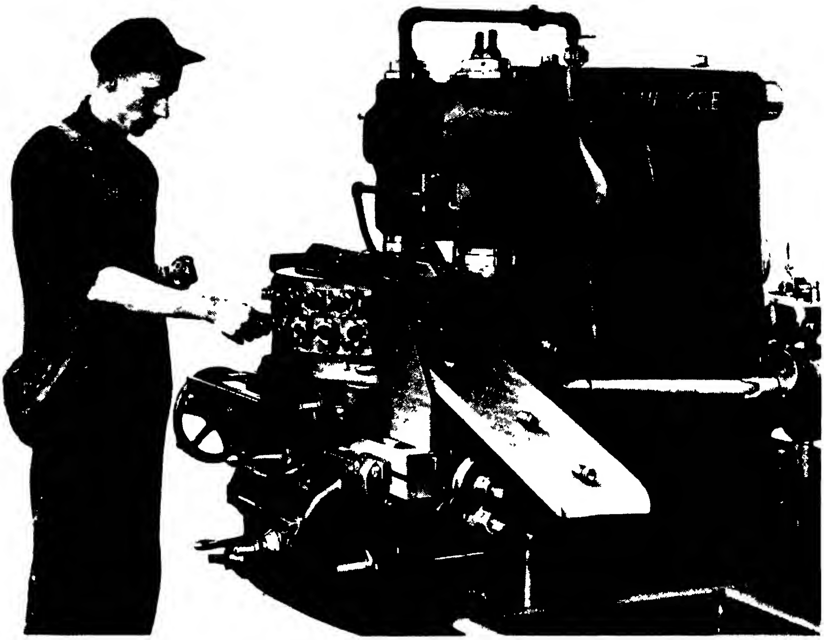
The period between 1870 and 1900 was marked by the rapidly growing aggregation of capital and the development of large industrial units. Partially, as a result of the development of the interchangeable system of manufacturing, there was a widespread introduction of labor-saving machinery. The great improvements in mechanical processes and the economies growing out of mass production resulted in the rapid development of industrial prominence by the United States. The further division of labor and transfer of hand skill to machinery resulted in the enlargement of the group of semiskilled or unskilled labor. In large industrial units there was a gradual loss of contact between the employees and management. In many industries, it became almost impossible for the average worker to engage in manufacturing independently. Keen competition threw the question of labor costs into sharp relief and caused unduly low wages in many instances. Resulting conditions caused the organization of many of the great labor unions. The American Federation of Labor had its beginning in 1881.

After 1890 there was a rapid growth in the corporate form of ownership. The horizontal and vertical integration of industry proceeded on a large scale as the benefits of mass production and the control of materials and markets were realized. The extent to which

competition was controlled or eliminated aroused a fear in the public that the means of production might become unduly controlled by capitalists and the leaders of industry, to the detriment of the public interest. As a result, between 1900 and 1910, laws for the control of the so-called "trusts" were passed by Congress and the legislatures of the various states. This tendency toward extensive integration resulted in many cases in a considerable separation of the control and operation of our great industries. Today, there are many large corporations whose general offices are located in some great industrial or financial center. The high executives are interested chiefly in the financial control of the corporation. The actual operation of its plants, which may be located at widely separated points throughout the country, is delegated to subordinate managing executives stationed at these plants. There is likely to be a complete loss of contact between the employees and those who control the industry. Policies are considered from a financial viewpoint to such an extent that the interests of the employees are not properly appreciated. The movement tends to divide more sharply those who own, manage, or operate. Grievances which may be insignificant in the beginning, are allowed to grow until they cause a loss of morale and individual efficiency, and in some instances develop into serious trouble. In order to overcome this condition, many corporations have established personnel departments which deal solely with problems of labor relations.

After a certain point has been reached in the integration of industry, there is likely to be a gradual loss of efficiency as the industrial units become larger and larger. They are affected by the law of diminishing returns. Those to whom the functions of management are delegated may not display the same interest and efficiency as the owner and manager of the small plant, although their knowledge of management may be greater. Employers and employees no longer have a close community of interest. The worker is apt to do the least that he can do and hold his job. There is a tendency to outgrow the methods which may have been satisfactory in the past without realizing that this has taken place. Usually, no proper study of the development of modern management methods is made until conditions become acute.

**The Development of Modern Management Methods.** Realization of these conditions led Frederick W. Taylor to develop his philosophy of scientific management. While connected with the Midvale Steel Co., Taylor was impressed with the fact that there is great waste in industry due to the fact that men, materials, and machines are not used to the best advantage. From 1880 to 1903, he developed fundamental policies and methods which are the basis of modern management today. In



*Courtesy—Kearney & Trecker Co.*

PLATE 1

A Semi-Automatic Milling Operation

1890, he left Midvale to engage in consulting practice. In 1895, he published an article on his piece-rate system, which included a statement of his philosophy of management. This article received widespread attention and had a considerable effect on management thought. Unfortunately, the majority of business men seized the idea of piecework without realizing that a sound, rational basis of management is necessary for the successful operation of any system of wage payment in proportion to production. In 1898, he was employed by the Bethlehem Steel Co. and resumed his development of management methods. His study of the handling of pig iron at this company is a classic example of job standardization and the application of the principle of wage payment in proportion to production. Because the public, for the most part, had failed to appreciate the principles of management that he had announced, he wrote his paper on *Shop Management,* which was presented to the American Society of Mechanical Engineers as his presidential address, in 1903. While many of the methods outlined in this book have been rendered obsolete by modern developments, the principles which he laid down are fundamental.

Following the termination of his connection with the Bethlehem Steel Company, in 1901, he engaged in the installation of his methods in various plants, research in management problems, and in popularizing his philosophy. The Link Belt Company and the Tabor Manufacturing Company are two of the best known of these installations. Taylor and an associate, Maunsel White, conducted a series of investigations of the laws governing the cutting of metals. One of the results of these experiments was the discovery of high-speed steel, which revolutionized the machine-tool industry and metal-working methods. The results of this work were presented in 1906, in his paper entitled, *The Art of Cutting Metals.* Mr. Taylor's remarkable work in the advancement of the science of management makes him the outstanding pioneer figure in this field. He continued his work until his death in 1915.

Associated with Mr. Taylor were a number of men who later carried on and extended his work. Of these possibly Carl Barth and H. L. Gantt are the most notable. Barth has contributed considerably to the literature of scientific management, and Gantt is known for his *Work, Wages, and Profits* and other writings. Both engaged widely in the installation of modern management methods. Mr. Gantt died in 1922. There are many other names, such as Henry R. Towne, H. K. Hathaway, Frank B. Gilbreth, Sanford E. Thompson, Morris L. Cooke, and James M. Dodge, that will always live in the literature of scientific management. One of the outstanding management pioneers is Harrington Emerson. Although a contemporary of Taylor's, his development of the principles and practices of modern management was

conducted independently. Through his writings and oral statements he has profoundly affected scientific management thought.

**Developments Since the World War.** The World War did much to focus the attention of industrial leaders on the question of scientific management. The necessity for utilizing available productive resources to the utmost made it necessary to examine management methods more carefully than ever before. The Ordnance Corps of the United States army had a section which specialized in the work of bringing up the operating efficiency of the plants which supplied the needs of the army. Much was written on the question of scientific management which tended to familiarize the public with it. During this period, and the post-war boom of 1919 and 1920, many industrial organizations engaged independently in the work of modernizing their management methods.

With the depression of 1921 some of this work fell by the wayside. Yet, it is interesting to note and most hopeful, that today a large number of industrial leaders are continuing the work. Such contributions as *Waste In Industry* and *Business Cycles and Unemployment,* which resulted from the President's Conference on Unemployment, held in 1921, have done much to focus the attention of manufacturers on the need for more scientific management methods. The Department of Commerce, under the direction of Mr. Hoover, has been very active in many phases of the work of promoting greater efficiency in the operation of American industry.

**Taylor's Philosophy of Management.** The work of management consists of the determination of policies, the development of methods, the building of organizations, and the operation of these organizations for the economic production and distribution of goods and services.

Dr. Taylor defined management as "knowing exactly what you want men to do, and then seeing that they do it in the best and cheapest way." [1] It is too often the case that the management of a concern may know what it wants men to do, but it has no exact knowledge of what constitutes the best and cheapest way. The operating methods employed are largely the result of past experience. In many instances they have been developed under conditions of business which no longer exist, and as a result the methods may be entirely inadequate. No logical or continuous effort is carried on to analyze operating problems with regard to the operating methods employed. Taylor's definition of management implies the application of methods of scientific analysis to the solution of business problems. The use of analytical methods is one of the foundation stones of scientific management.

In *Shop Management* there are four ideals of management that

[1] *Shop Management*, by Frederick W. Taylor, p. 21.

run through his discussion as a central theme: (1) *High wages* should be paid to the employee for the attainment of exact, accurate, and just standards of production. Taylor felt that an important cause of low wages and high costs in industry is the ignorance of employers and their foremen as to the time in which various kinds of work should be done. Furthermore, this ignorance is shared largely by the employee. The piece rate that is set by a foreman, and then cut because of unusually high earnings of the employees is a familiar example of this ignorance. The amount of work that a good workman can do without detriment to his health should be determined by careful analysis and study of the elements of the operation. This standard of production should not be modified unless there is some distinct and material improvement in the method of performing the operation. (2) High wages as the result of the greater and more efficient application of the employee to his work, together with the more efficient application of machines and materials, will result in *low unit costs.* Mr. Ford has amply demonstrated the correctness of this principle. (3) The maintenance of a *proper standard of quality* should be carried on with the development of better methods of management. In most instances it has been found that with the development of the inspection function, the determination of the best methods of processing and the instruction of the employees in these methods, the offering of wage incentives has increased rather than decreased the quality of the product. (4) Taylor's plan of organization recognized the existence of the personnel function. He realized that unless personnel problems are handled intelligently and good working conditions are provided, industry cannot hope to get maximum production from its employees. In this connection, he stated that he had never failed to get great gains in production from the *betterment and standardization of working conditions.*[1] The experiences of management consultants who have come after him have corroborated his views.

It was Dr. Taylor's belief that in order to attain these ideals there must be (1) a large daily task for the workman, (2) standard conditions under which the task is performed, (3) high pay for success in the performance of the task, and (4) loss for the workman in the event that he fails to attain the standards of production and quality.[2] In connection with a large daily task, he felt that each workman should be given as far as possible, the highest grade of work for which his ability and physique fit him. Furthermore, he should be required to turn out the maximum amount of work which a first-class man of his grade can do without injury to himself. As an inducement, he

[1] *Shop Management,* by Frederick W. Taylor, p. 124.
[2] *Ibid.,* p. 63.

offered a wage incentive for the attainment of the production standards which varied from 30 per cent to 100 per cent of the going rate of wages, depending on the class of work. It is the usual practice to penalize the worker for failure by the loss of his bonus earnings for the task, and by deductions for the work which does not meet the standards of quality. From the standpoint of accuracy and facility in setting and maintaining production standards and ability to preplan production, the standardization of such conditions as heating, lighting, ventilation, and equipment is essential.

Dr. Taylor pointed out the "exception principle" [1] in management. Briefly, this recognizes that the manager is not interested in the administration of routines that are operating effectively. He is interested vitally in those that are not. Accordingly, managerial reports should be condensed, summarized statements which compare current results with performance standards. In such reports, the important variations from these standards should be pointed out.

The backbone of Taylor's philosophy was the application of the methods of scientific collection of data, analysis, and synthesis to the solution of managerial problems. It is certain that with our high standards of living, high wages, increasing competition at home and abroad, and increasing complexity in industry, the scientific method of attack will become more and more a necessity in the development of efficient management methods.

Many of the early obstacles to the introduction of such methods are disappearing. The opposition of organized labor seems to be gradually melting away. The pseudo efficiency expert has largely passed into history. In his place has come the competent management specialist. As a result of these and other changes, the development of scientific management methods in America is proceeding on a sound basis, slowly but surely.

[1] *Shop Management*, by Frederick W. Taylor, pp. 109–126.

# CHAPTER II

## PLANT LOCATION

**The Importance of Proper Location.** The location of the plant is often an important factor in its success or failure. On it may depend our ability to serve customers satisfactorily, to obtain an adequate and continuous supply of raw material at minimum cost, to maintain a sufficient, competent, labor force and many other factors in manufacturing. Sometimes a poorly managed plant is able to enjoy a considerable measure of success because of a good location, while a well managed plant in a poor location has difficulty in competing.

Although a manufacturer may be operating successfully in a given location, he has no assurance that he will not be faced with the problem of plant location some time in the future. Habits and customs, centers of population or trade, channels of communication and transport, are constantly changing. A plant which is operating successfully on a given site may find, ten or twenty years later, that it is no longer economically well situated.

When the problem arises, the manufacturer will find that the selection of a proper location involves a number of economic factors, some of which are rather intangible. A satisfactory solution is one which is usually outside of the experience of the average manufacturing executive. Therefore, it is advisable to seek the aid of competent counsel.

**Major Factors Affecting Plant Location.** The major factors affecting the location of the plant, are (1) the relation of the site to material supplies, (2) its relation to the markets in which the product is distributed, (3) the character and availability of transportation facilities, (4) the labor supply, and (5) power.

In many industries the relation of the site to supplies of raw material may be the dominant factor in its selection. If the raw material is costly, heavy, or bulky, it may be more economical to ship the finished product than to ship the raw material. The farther the site from the sources of materials the larger are the reserve stocks of materials that must be maintained. More capital is tied up, interest charges on raw-material inventories are larger, greater storage space is required, and handling charges may be increased. In addition, there is more danger that the flow of materials to the plant may be interrupted by transportation difficulties, with consequent losses due to interruptions to plant

operations. In some industries, the material factor apparently is of prime importance. However, its influence may be modified considerably by the presence of other economic factors in the problem. The great sawmills necessarily follow the receding forests. But iron ore is shipped many hundred miles by lake or rail. As the proportion of the direct material cost to the total cost of the product decreases, the importance of the material factor decreases, although not necessarily at the same rate, because of the importance of storage and continuity of supply.

The relation of the site to markets may be very important in the case of small plants that serve a local or an emergency demand. Ice-cream plants are located in or near the cities that they serve. A machine-repair shop must be located near the industries that it expects to serve.[1] Furthermore, there must be a sufficient number of plants that need such outside repair service, to support the plant. Often, plants which serve more than local demands may find it advisable to give the market factor first consideration in selecting a site. Nearness to its principal markets may increase the promptness with which the plant can serve its customers. If the cost of shipping the finished product is greater than the cost of shipping the raw material, nearness to markets may effect considerable savings in transportation charges. The desire of buyers to inspect and choose goods in large buying centers may make it advisable to locate near such centers. It is said that this has been one of the factors which has retarded the growth of the cloak and suit industry outside of New York City. In general, it is natural for an industry to locate near the market that it serves. Where there are a number of markets, the selection of the proper location, in so far as the market factor is concerned, is a matter of balancing such considerations as population, purchasing power, and buying habits against one another.

Other things being equal, the best location, from the standpoint of transportation, is that location at which the cost of moving raw and worked materials to and from the plant is a minimum. It has been previously pointed out that transportation costs and service may be an important factor, tending to locate the plant near the source of raw materials or near the markets for the product. Those cities which are served by a number of railroads usually have more favorable tariffs and better service than those which are served by a single road. There will probably be a number of choices of routings for the incoming and outgoing shipments. The manufacturer who is located in a city served by a single road may find that his transportation costs are as high as, if not higher than, those of his competitor in the railroad center and

[1] See *Maintenance Department*, p. 216.

that he has greater difficulty in getting cars whenever there is a car shortage. Many cities have a belt-line railroad connecting the principal roads. A car loaded at a plant on the belt line can be switched to any road coming into the city. Transportation costs are reduced by the greater facility in loading and unloading cars and by the elimination of trucking to the siding of the particular road over which the shipment is routed. In large railroad and industrial centers, sites near such belt lines are very desirable and sell at high prices. In Cleveland, Ohio, for example, some are reported to be valued at $50,000 per acre or more. The junction points of railways and waterways often offer desirable market opportunities as well as transportation facilities. Obviously, if the transportation cost is a small part of the total cost of the product, the necessity of locating near either the source of raw materials or the markets may be greatly diminished. These and similar considerations must be weighed when the transportation factor is evaluated.

The character of the labor supply may affect the selection of a site in a number of ways. If wage rates are high, labor costs may be high also. However, this may be modified by the character, intelligence, and cooperativeness of the available labor. If the trades which must be used are highly unionized, the introduction of modern management methods may be hampered and per capita production may be low. On the other hand, skill and familiarity with the work may offset these considerations. Skilled workers accustomed to earning good wages, cannot be moved from one community to another easily. Often they own their homes and have established ties of other kinds that bind them to the community. For these reasons, industries that otherwise are located uneconomically sometimes persist and thrive in the localities in which they originally developed. An important consideration is the adequacy of the labor supply to meet varying production demands. It involves the extent of training, welfare work, housing, and other employee service work that must be undertaken. In some industries, such as the high-grade furniture industry, the extent, kind, and character of the labor supply may be the chief consideration in the location of the plant.

Cheap power often attracts industries, particularly those in which the power cost is an important element in the total cost of manufacturing. There are a number of large electro-chemical plants near Niagara Falls, due to the availability of relatively cheap electric power. Cheap coal has been an important factor in building up the Pittsburgh manufacturing district. With the majority of industries, power costs are a major factor to be considered in locating a plant. With the growth of large central stations and the development of super-power projects,

an increasing number of concerns are purchasing rather than producing power, finding it more economical. They are relieved of a heavy investment in power-plant equipment. The operation of a power plant results in a considerable power charge whether the plant is producing or is idle. When power is purchased, the power charge fluctuates more closely with the fluctuation in the volume of production. Whether it is more economical to purchase or produce power depends to a large extent on the size of the plant, nature of the product, and the quality and cost of local power service. Those industries that use large quantities of steam in their processes, as in the manufacture of rayon, often find it more economical to generate their own power.

**Minor Factors Affecting Location.** The minor factors affecting plant location are (1) the cost of land and buildings, (2) the possibility of expansion, (3) service industries, (4) financial service, (5) water supply, (6) water and tax rates, and (7) labor legislation.

The cost of land and buildings varies considerably between manufacturing communities. The cost of desirable sites ranges from a few hundred dollars per acre or less, in the smaller towns and cities, to many thousand dollars per acre in many cities. In cities in which the building trades are closely organized the cost of erecting factory buildings may be high. The interest charges on land and buildings are often a considerable item in the indirect expense of manufacturing. Furthermore, if land is reasonably cheap, sufficient acreage can be acquired to permit the location of buildings in such a manner that their relation to one another will facilitate maximum production. They can be constructed to meet the needs of the particular business. If land is very valuable, the cost of land for certain types of construction, such as single story, saw-tooth buildings may be prohibitive.

A related consideration is the availability of land for expansion. If a business prospers, eventually it may become necessary to erect additional buildings or to make additions to existing ones. If it is necessary to erect new buildings at a considerable distance from the plant, administrative difficulties are created.

The presence of service industries may be important to some plants, particularly the smaller ones. If the industry is not self-contained, it may require the services of foundries, machine shops, parts manufacturers, public warehouses, and various other service agencies.

The strength, progressiveness, and far-sightedness of the community are important factors. Their willingness and ability to cooperate in financing the activities of the company may contribute materially to its success.

To some industries, using large amounts of water in the generation

of power or in industrial processes, the nature of the water supply and water rates may be important.

Taxes are an important item of indirect expense. The tax rates and their application in the communities under consideration must be investigated in selecting a plant site.

In some instances state labor laws may be a factor. Many of the Southern states have attracted plants from the North because their factory laws are less strict.

**Classes of Plant Sites.** Plant sites may usually be grouped in four classes—those located in (1) large, (2) small, (3) suburban, and (4) specialized manufacturing communities. The last named class is really a special case of the three preceding classes.

**Large Manufacturing Communities.** Large manufacturing centers, such as Buffalo, Chicago, Cleveland, Detroit, and Philadelphia, have many manufacturing advantages to offer. They are served by a number of competing railroads. In many cases they are equipped with belt lines and in general have excellent transportation facilities. Usually, they have an abundant supply of all classes of labor. In most cases one of the greatest difficulties in building an organization is in securing sufficient minor executives and skilled labor. At most times such help can be secured in the city on relatively short notice. Furthermore, trade schools and technical high schools are constantly maintaining the supply. Discussion groups, such as the sales, production, and employment-managers groups, often organized and conducted under the auspices of the local chamber of commerce, have a stimulating effect on executives, aiding in their development. The large manufacturing community is well equipped with theaters and other amusement places. Its amusement and educational advantages are such that the necessary amount of plant welfare work of this kind is a minimum. Often it is a good market for the product, particularly in the case of the small plant. It is well supplied with service organizations of the kind which have been mentioned. Power usually can be purchased from central stations at reasonable cost. This also is a distinct advantage for the small plant. Finally, the large city offers superior financial resources and services.

Against these advantages must be set a number of disadvantages of sufficient importance to induce many manufacturers to move their plants from the larger to the smaller manufacturing communities or to establish branch plants in them. In the large cities, land is expensive and the number of desirable sites is limited, making expansion of the plant difficult. Taxes are relatively high. The cost of living usually is higher than in the small town, and wage rates are correspondingly higher. In some of the larger cities, the labor situation in certain

trades is dominated by powerful city federations of labor. If the trades which must be used are highly organized, there is the possibility of lower production per man and labor trouble. In the city the presence of small loft concerns in the industry may disorganize local markets and the labor situation. The distances which the workers must travel to and from their work are great. Sometimes a site may be suitable in other respects, but the distance from a car line and from the working-class residential districts may be such that it would be difficult to maintain labor forces. Many manufacturers feel that the appearance of their grounds and buildings is a good advertisement, and a factor making for the contentment of their working force. The closely built, smoky industrial districts of large cities offer little opportunity for beautifying the plant and its surroundings. The grounds of the National Lamp Works' laboratory at Nela Park, on the outskirts of Cleveland, are beautifully parked. The contrast with the appearance of many plants in the city is striking.

**Small Manufacturing Communities.** In many cases, the manufacturer in the small community is not hampered by conditions that add to the costs of the city manufacturer. Often he enjoys better labor conditions. His labor is more likely to be native-born and more intelligent. A larger percentage own their own homes and are permanently attached to the community. Because of lower living costs, they can enjoy a higher standard of living on a lower wage level. In many cases the plant is a dominant factor in the life of the community. For this reason it is possible for the plant executives to enjoy closer and more cordial relations with the working force, provided that they do not abuse the power which their position gives them. For these reasons, and the absence of powerful local labor organizations, the probability of labor troubles seems to be much less than in the larger cities.

Usually land is cheaper and construction costs and taxes are less. Sufficient land can be secured easily for present and future needs. The small town or city often has a highly developed community spirit. To induce manufacturers to locate in the community, such inducements as a free factory site or rebates of taxes may be offered. Its chamber of commerce may sponsor the sale of securities in the community and induce local banking interests to finance the construction of a plant and the operations of the new company. Such inducements are tempting, particularly to the firm that is not strong financially, and often lead to the improper location of the plant. The executives are apt to overlook the fact that there are other economic factors in the location of the plant besides cheap land, plant, and taxes. The penalty for the disregard of these other factors may be the failure of the

company, after a few years of operation, to the detriment of the community which has sponsored it.

As opposed to the advantages of the small community, there are a number of disadvantages. Educational and amusement facilities may be limited. If the company must build up its working force by bringing in workmen from other communities, this lack may make it difficult to maintain an adequate working force. The majority of the better workmen want proper educational facilities for their children and to some extent for themselves. In some instances, particularly in the company-owned towns of large corporations, it has been found desirable to establish public schools, company schools, apprentice training, or to engage in other educational activities. It may be necessary to make considerable expenditures for recreational and amusement facilities. If city workers are brought to the small community and such facilities as movies, theaters, and amusement parks are lacking, it may be necessary to supply them to keep the workers contented. Important executives who enjoy large salaries may feel the lack of social advantages, which may make it difficult to hold them.

The small manufacturing community may not have a broad labor market from which an adequate labor supply of all kinds can be drawn on short notice. If workers are imported in large numbers, housing problems may be created. Before a large permanent increase in the working force can be made, it may be necessary to make a considerable investment in workers' homes.

In addition, the small manufacturing community may be less desirable because of inferior transportation facilities, absence of a local market for the product and other advantages that the city can offer.

**Suburban Locations.** In recent years there has been a marked movement of manufacturers from the larger cities to suburban locations. In many respects, such locations combine the advantages of the city and the small community, without their disadvantages. Suburban manufacturers are able to draw on the neighboring city for labor. Their employees are able to enjoy better living conditions, are more contented and probably more stable. Educational facilities usually are good. To a large extent, the employees can avail themselves of the amusement facilities in the city. In many cases the transportation facilities of the suburb are nearly as good as those of the city. While wage rates and construction costs may not be much lower than in the city, land costs and tax rates usually are lower. The more important executives can live in or near the city, enjoying the advantages of city life. For these reasons the suburban manufacturing community seems to be coming into favor.

**Specialized Manufacturing Communities.** Certain cities have become noted for certain kinds of manufactures. Akron is noted for its rubber products; Detroit for the manufacture of automobiles; Grand Rapids for furniture; Battle Creek for breakfast foods. While other manufactures are produced, they are noted chiefly for these products.

While such communities are special cases of the preceding classes, they have certain advantages peculiar to themselves which make it advisable to consider them separately. They have an abundant supply of labor skilled in the processes carried on in the industry. Often the community maintains trade schools which continually augment the supply. As a result, the amount of training which the individual concern must carry on is reduced. Because of the large number of concerns in the same industry, materials and supply dealers can carry larger and more varied stocks. The purchasing department can often obtain necessary materials and supplies on short notice from local sources. For the same reason, the specialized community probably is well supplied with various service organizations peculiar to the industry. It may be easier to finance operations because local bankers are thoroughly familiar with the needs of the industry. Similarly, a new concern in the industry probably will find it easier to dispose of its securities because local investors have the confidence born of previous successes. Finally, the fact that the concern is located in a city that is noted for the products that it intends to manufacture gives it a certain prestige. The reputation of the city for such products attracts buyers over long distances and results in a desirable local market. Grand Rapids with its furniture shows is an example of a specialized community.

**Relative Advantages of Locations.** The relative advantages of the different locations which have been discussed depend largely on the nature of the problem of the particular concern. In general, the large concern which is more self-contained with regard to its operations can settle in the small community to better advantage than the small concern. The city with its varied service organizations, excellent educational and amusement facilities, broad local markets, good labor supplies, cheap central-station power, and other advantages seems better for the small plant. There has been considerable movement of large concerns from the large cities to suburban or small community locations which apparently substantiates this view.

**Sources of Information for Plant Location.** The modern manufacturer who finds it necessary to relocate his plant or to establish a branch plant has a number of sources of information to aid him in the solution of his problem. Numerous books and articles on the subject have been written. Many chambers of commerce in manufacturing communities

maintain industrial bureaus which furnish information relating to the economic advantages of their communities for manufacturing. The industrial agents of railroads and electric-power companies are glad to give similar information relating to locations on their lines. Census reports and various reports of the Department of Commerce are often helpful. There are a few consultants who specialize in this field. From these sources data can be obtained that will permit a satisfactory solution of the problem of plant location.

# CHAPTER III

## THE PLANT AND ITS EQUIPMENT

**The Importance of the Plant.** The building in which the workers and equipment are housed is something more than a protection from the elements. It is an item of productive equipment. If the best type of machinery for a given process is selected and if properly designed with regard to the conditions under which it must operate, we can get maximum production. Similarly, the selection of the proper type of building and its proper design can materially aid production. Obviously heavy foundry operations, which give out gases and require crane service for moving heavy loads, cannot be conducted economically in a building having low ceilings. While the relation may not be so obvious in all cases, the building usually is an important factor in the economy of manufacturing.

A great many successful concerns have grown from small beginnings to considerable size. The buildings in which they are housed have grown correspondingly. The present plant often consists of a series of accretions to the original building unit. As the business has grown, manufacturing problems have changed. Unless the management has shown unusual foresight, it is probable that the nature of the plant makes minimum cost production impossible. It may be difficult to maintain a smooth flow of work through the plant with a minimum movement of material. The difficulty of supervising activities may be increased. In many other ways, the cost of production may be increased because the building is poorly adapted to the requirements of present manufacturing conditions.

Sooner or later most successful manufacturing concerns find themselves forced to build new plants or make additions. Errors in selecting the type and design of building cannot be corrected easily. Therefore it is desirable that responsible executives have some general knowledge of the characteristics of industrial buildings.

**Factors Affecting the Type of Building.** Some of the factors which affect the selection of the type of building are (1) visual control of activities, (2) economy in the movement of materials, (3) the value of land, (4) the nature of the industry, (5) the nature of the processes, (6) permanence and resale value.

In many respects it is an advantage to have the manufacturing operations performed on one floor, with the view of the shop obstructed

as little as possible by columns. Executives can be located more easily. Jobs can be traced and located more quickly. Many other advantages result from the use of single-story buildings.

Economy in the movement of material may affect both the type of building selected and its design. In some buildings, runways for traveling cranes must be provided. Machinery and equipment must be laid out so that work flows through the plant with a minimum of moving between operations. With many thousands of dollars in material and work in process flowing through the plant, economy in the movement of materials is necessary for rapid turnover of working capital and low cost production.

If land is expensive, single-story buildings may not be desirable for financial reasons. Too much capital may be tied up in the plant site. Interest charges and taxes may be too large. Desirable factory sites may be scarce and it may be difficult to secure sufficient land. For these reasons, it may be necessary to select a type of building which requires less land. Any loss in the economy of manufacturing must be balanced against the above factors in the cost of production.

Some concerns may manufacture a single product or a few products of a similar nature. These may be manufactured in large quanities. Under normal conditions, there may be a continuous flow of work through the plant. The division of labor may have been developed to a high degree. Special machinery of an automatic or semi-automatic character may have been introduced. Conveying equipment of an elaborate nature, peculiar to the industry, may be necessary. Such factors may result in the development of a type of building that is peculiar to the industry. In some industries the materials that enter into the product are brought together at or near the starting operations and travel together through the various processes until they are worked into the finished product. In other industries, the product may be an assembly of a number of parts fabricated from different materials, which travel through different processes and sequences of operations until they reach the final assembly floor. In such cases, it may be advisable to establish sub-storerooms for certain materials, near the operations which use them, in order that they may be easily and quickly supplied at a minimum cost of moving. In these and in many other ways the nature of the industry may directly affect the determination of the type of building to be used.

Similarly, the nature of the processes may be a factor. Heat-treating processes give off heat, smoke, and gases. They should be separated physically from the other operations. The jar and shock of the drop hammers may affect the adjustment of delicate machinery used in certain processes, and make it necessary to place the drop forge shop in a

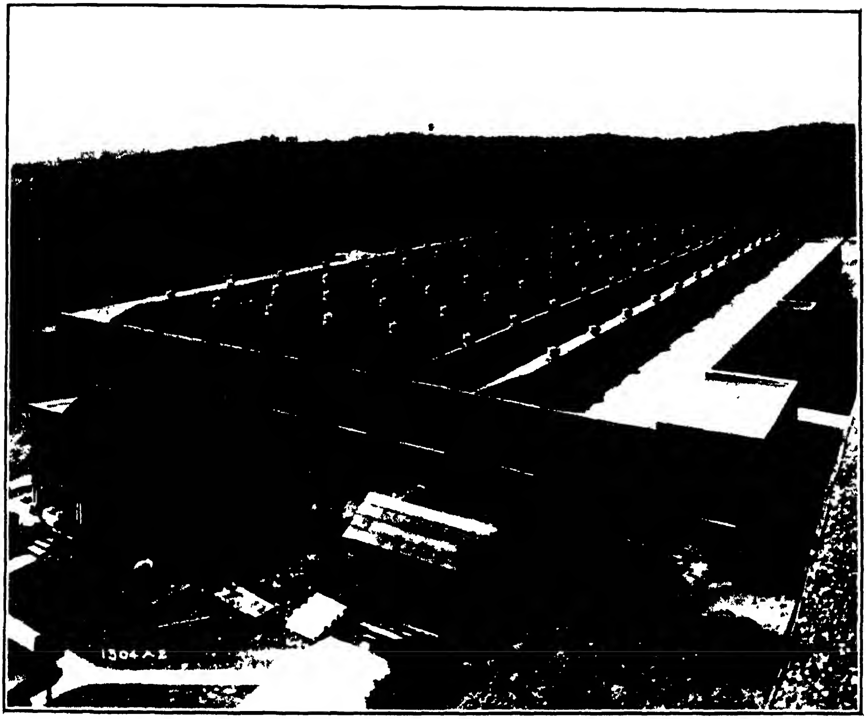
separate building. The buildings for these shops will be quite different from those used to house light manufacturing operations. Dean Kimball uses a continuous-process stamp mill to furnish an interesting illustration of the effect of processes on the type and design of the building.[1] The plant is built on the side of a hill in order that the force of gravity may be used to carry the ore through the processes.

In a few instances the permanence of the industry may be a factor. A manufacturer of novelties might find it profitable to expand his plant capacity to take advantage of an extensive demand for some new item. It is difficult to tell how long the demand will last. If he uses permanent construction, the type of building must be such that it meets the general requirements of the class of novelties that he manufactures. It cannot be built to meet the specific requirements of the new novelty. In exceptional cases, the desirability of the present location or the demand may be temporary. Under such conditions, the buildings should be of a type that will meet the requirements of a wide range of industries in order that they may be sold eventually at the best possible price. Again, this factor may be more important than construction to meet the specific needs of the industry. During the late war many plants were expanded without thought of the possibility of having to sell a part or all of the capacity in excess of normal requirements. In some cases the concerns were forced to take serious losses, partially due to this lack of foresight.

**Types of Industrial Buildings.** Most industrial plants can be classified into four types: (1) single-story buildings with either a flat or saw-tooth roof, (2) monitor types, (3) multi-story buildings with either a flat or a saw-tooth roof, and (4) special types.

The single-story building has a number of advantages. When equipped with a saw-tooth roof, as in Plates 2 and 3, the natural illumination in the shop is excellent. Almost any desired width of building can be had. The building can be expanded easily as more space becomes necessary. With special truss construction, 100-foot spans between columns are possible. As a result, manufacturing space is broken up as little as possible. There is a relatively unobstructed view of operations which is often an aid in controlling them. Inasmuch as all manufacturing space is on the same level and is relatively free from obstructions, there is greater flexibility in the arrangement of equipment. If necessary, heavy machinery can be placed on foundations set directly into the ground, thereby reducing the amount of vibration throughout the building. Little non-productive space is required for elevator shafts, stairways, and other service features that are peculiar to the multi-story building. The cost of moving materials usually is

[1] *Principles of Industrial Organization*, by Dexter Kimball, p. 78.



*Courtesy—Lockwood, Greene & Co.*

PLATE 2

SAW-TOOTH CONSTRUCTION

*Courtesy—Lockwood, Greene & Co*

PLATE 3

GOOD NATURAL LIGHTING WITH SAW-TOOTH CONSTRUCTION

less because the distances through which they are moved are shorter and no material handling equipment is necessary for moving between floors. Saw-tooth construction or skylights give good natural ventilation. When properly designed, these and other advantages make the single-story type of building very desirable for many types of manufacturing. Its chief disadvantage is that the cost of land and construction per square foot of floor space is high. Where land is scarce and expensive this may prohibit its use.

Plate 4 shows a building of the monitor type. The roof truss is surmounted by a monitor. Such buildings are usually constructed with steel frames, with or without concrete reinforcing. In most cases they are designed to give the maximum head room and cubical content per unit of floor space. Often they are constructed with mezzanine floors in the side bays for light manufacturing. The side walls can be designed so that almost 100 per cent of the effective lighting area is in glass. Such design provides excellent illumination, provided there is a good janitor service that keeps the windows clean. The monitor gives good natural ventilation. This type is frequently used for heavy manufacturing or assembly operations, requiring crane service and considerable head room, or for housing processes which, in addition to requiring crane service, give off considerable heat and gases, such as foundries and heat-treating shops.

The multi-story building has the advantage that it gives a maximum square footage of manufacturing floor space per square foot of ground space. For this reason, it may be desirable when land values are high. It is well adapted to light manufacturing. In the case of an assembled product, the operations on the different parts can be laid out so that all work moves in the same general direction to the assembly floor, with a minimum of moving between floors. Fig. 1 shows a layout of operations in a multi-story building which approximates a straight-line flow. If the material is not bulky or heavy and proper material-handling equipment is provided, the cost of moving raw and worked materials will not be excessive. On the other hand, the multi-story building has a number of disadvantages. The problem of moving materials is more complicated than in the single-story building. More time is spent by individuals and materials in moving between departments and floors. More dead space for elevators, stairways, and fire-escapes must be provided. Head room and floor loads are limited, unless special construction is used, which is usually expensive. The width of each building unit is limited. The usual multi-story factory is from fifty to seventy feet wide. Beyond this width, the natural illumination in the center of the shop is apt to be poor, even on bright days, unless special construction is used. For most manufacturing purposes, either the single

story or the monitor type building is better than the multi-story type, provided financial considerations do not prevent its use. Under most conditions, the four-story standard factory building has the lowest cost per square foot of floor space. Above four stories, the cost of construction increases rapidly. Better foundations, heavier steel work, thicker walls, more elevator service, and generally expensive construction must be used. Plate 6 is an example of a multi-story factory building.

In many cases, the buildings of a plant are combinations of the three general types. In other cases, the building is specially constructed to accommodate the particular needs of the business. Such buildings may be classed as special types.

**Types of Factory Construction.** The more common types of factory construction can be grouped in five classes: (1) wood-frame construction, (2) brick construction, (3) slow-burning mill construction, (4) steel-frame construction, and (5) reinforced concrete.

Wood-frame construction depreciates rapidly and insurance costs are high, because of the fire hazard. It can be erected quickly and cheaply and alterations can be made easily. It is usually used only for temporary buildings.

With brick construction the side walls and fire walls are brick. The beams are carried on the side walls, necessitating the use of relatively thick pilasters. As a result, the amount of wall space that can be put in glass is reduced. It is more permanent than wood-frame construction and depreciation charges are less. With ordinary brick construction, the fire hazard is considerable and insurance rates are high. Alterations and extensions of the plant can be made with relative ease. It is a type of construction that is not generally used by modern plants.

A type of brick-and-wood construction that has been used considerably is the slow-burning mill type. The theory of this type of construction is that a fire can be localized for a considerable time if the construction is heavy enough to prevent it from gaining headway easily. An opportunity is afforded to get it under control before it assumes serious proportions. Such construction is characterized by the use of heavy timbers and planks so that the fire must burn deeply before the columns and floors fall or it eats through to other floors. Ten-inch beams and three- or four-inch floor planks are often used. The building is broken up into manufacturing rooms by means of fire walls at frequent intervals. Each room is a self-contained fire unit, being separated from other rooms by means of fire doors. All openings between floors, such as elevator shafts, should be incased in slow-burning construction and designed so that they can be closed off completely from the floors onto which they open. Hollow passages between floors through which

fire might pass are eliminated as far as possible. The corners of all woodwork are rounded to make it difficult for it to catch fire. Ceilings are equipped with sprinklers. Every precaution is taken to make it difficult for fire to gain headway. Insurance rates on this type of construction are lower than on other types, with the exception of reinforced concrete equipped with sprinklers. The massive construction produces a permanent structure which transmits the vibration of machinery to a much less extent than the preceding types. Yet it is relatively easy to cut openings and to make alterations and extensions. The slow-burning type is still the cheapest construction in most cases.

Steel-frame construction is characterized by the use of steel columns, beams, girders, and roof trusses. The outside and fire walls usually are brick curtain walls, erected between the columns. In some cases the side walls are constructed of corrugated sheet steel. Such buildings are hard to heat and are suitable only for housing processes which give off considerable heat. The corrugated steel siding depreciates rapidly, even when properly protected. Floors are constructed of wood, hollow tile, or concrete. The roofs usually are constructed of planks laid on steel roof trusses and covered with some fireproof roofing material. All steel work should be fireproofed with concrete or other suitable material to prevent it from twisting and warping during a fire. This type of construction has the advantage of low first cost. The larger construction companies, specializing in industrial buildings, have standard designs in steel-frame construction that can be erected quickly. On the other hand, if the steel work is not properly protected, and light wood floors and roofs are used, the depreciation is more rapid and the fire hazard is greater than in the case of reinforced concrete buildings. However, it is easier to make alterations and extensions. This type has been used considerably.

Reinforced concrete buildings are being used to an increasing extent. Plate 6 shows an example of such construction. In this type steel framing, incased in reinforced concrete, is used. Floors usually are constructed of reinforced concrete. In some cases, they are solid reinforced concrete slabs supported directly on the columns. In others the floor slabs are supported on a system of girders running between the columns, and beams between the girders. The layout of machinery and equipment should be worked out in advance of building in order that provisions can be made for fastening the machinery to the floor in the proper locations. If wood floors are laid over the floor slabs, this is not necessary. If plain concrete floors are used, it will be difficult and expensive to rearrange machinery when such relocation becomes necessary. Inasmuch as the ceilings are concrete surfaces, special provision must be made for mounting shaft-hangers and other power-

transmission equipment, unless individual drive is used. This adds further to the difficulty in making future relocations of machinery. The side walls are made of brick or hollow tile curtain walls between the columns, or of solid reinforced concrete. The objection to the latter construction is that it is difficult to cut openings if extensions become necessary. In fact, future expansion should be planned in advance of construction, if possible. Otherwise it may be necessary later to remove considerable reinforced concrete around columns and girders. The roofs usually are constructed of reinforced concrete or hollow tile. In some cases saw-tooth construction may be used. While there are certain problems which must be solved if reinforced concrete is used, the increasing use of this type of construction would seem to indicate that its disadvantages are considerably outweighed by its advantages. It depreciates more slowly than any of the preceding types. There is relatively little fire hazard. As a result, charges for depreciation and insurance are low. Because of its great durability and the greater ease with which it is kept clean and sanitary, maintenance charges are low. Its rigid construction reduces vibration to a minimum.

By the use of "daylight" construction better illumination and greater building widths are possible. In this type of construction the side walls carry none of the floor load. A row of columns runs the length of the building about six feet from the side walls. In designing the floor slab between these columns and the side walls, it is treated as a cantilever. Inasmuch as the side walls carry none of the load, almost 100 per cent of the effective wall area can be placed in glass.

The development of standard designs and modern construction methods make it possible to erect reinforced concrete buildings almost as cheaply as slow-burning mill buildings. For these reasons reinforced concrete is coming more and more into favor.

**The Design of Industrial Buildings.** In the preceding discussion, only the more important features of factory buildings, that are of interest from the viewpoint of management, have been discussed. In addition there are a host of technical details that affect the efficiency of the building that must be considered by the designing engineer. Plant sanitation, the accessibility of plumbing, the appearance of the building, toilets and other service features, lighting, heating, and ventilation, fire protection, the character, location, and extent of floor loads, and similar problems will affect the design of the building considerably.

**Outside Consultation.** In most cases, the regular engineer and executive staffs are too busy with their regular duties to undertake the work of designing additions or new plants. Furthermore, their experience or training may not fit them to handle it satisfactorily. For these reasons, it is usually more satisfactory to employ the services of

*Courtesy—Lockwood, Greene & Co.*

PLATE 4

MONITOR TYPE CONSTRUCTION

Courtesy—The Austin Co.

PLATE 5

Interior View—Monitor Type Construction

an industrial engineer whose broader experience will permit him to harmonize the requirements of good management and design to better advantage. Working with architects, he can usually effect economies that will well repay the value of his services.

**Plant Layout.** In building a new plant or expanding an old one, plant layout is an important consideration. In fact, it is desirable that the layout of machinery and equipment be worked out tentatively before the work is started. Good plant layout reduces to a minimum the congestion resulting from the movement of materials and inventory charges on work in process. It facilitates production by making it possible for the operative to work more effectively and by simplifying the problem of the supervision and control of production.

**Considerations Affecting Plant Layout.** The more important considerations affecting plant layout: (1) the work as nearly as possible should flow through the plant in a straight line; (2) there should be a minimum movement of work between operations; (3) provision should be made for the quick, easy and cheap movement of work; (4) departments and service centers should be located so that production will be facilitated; (5) consideration should be given to the location of motive power equipment; (6) the nature of the product and processes and their relation to the layout must be considered; and (7) adequate working space should be provided.

The ideal condition is to have each lot of work move steadily in a constant direction, through the various operations performed on it, to finished stores or the shipping floor. In practice, it is not always possible to attain this ideal. However, the lot should double back as little as possible in the course of its travel through the shop. Otherwise, an excessive amount of time will be required to move a lot through the shop, and the constant passing of lots in different directions may cause congestion of the work. The same result is produced if adequate and quick means of transportation are not supplied or the transportation service is poorly organized. The work piles up around the operator, interfering with his movements. In bad cases it may overflow into the aisles, interfering further with the flow of work through the shop. A certain amount of work must always be stored at the machine. In laying out machinery, space should be provided for storing the material on which the operator is working and the next lot scheduled for his machine. In addition, he should have plenty of space in which to work. The work should be moved from the machine as soon as possible after the operation is completed. Unless adequate transportation service is provided, there is danger that the work centers will be converted into sub-storerooms for work in process, resulting in serious interferences with production. For these reasons, selection

and location of conveyors, elevators, cranes, and other means of transportation and the nature of the internal transportation service are important factors that must be considered in making a plant layout. Anything that reduces the distance through which material must be moved while in process, or speeds up its handling and rate of travel, reduces the time that it is in process, and as a result the interest charges on the capital that is tied up in it. The rate of turnover of this capital is increased.

Departments should be laid out with regard to the processes carried on within them, the problems of supervision, and the probability of future expansion. In a metal-working concern, the foundry may be located near the railroad siding, the storage yard, and those departments in the shop that have the first operations on the principal parts in the product. Within the shop, the set-up and arrangement of the departments may be affected greatly by the nature and sequence of the operations on these parts. In some cases it may be necessary to modify the principle of straight line flow to permit the grouping of departments that have similar processes in order that some executive who has the necessary skill and experience may supervise them effectively. In other instances, fast-growing departments must be located in those parts of the plant that can be expanded most easily. Service departments and centers should be located near the production centers that they serve. Sub-storerooms often carrying large stocks of certain materials are located near the departments that use the bulk of these materials. Inspection benches may be located in or near the department or operations that they serve. The locations of the final assembly floor and the railroad siding will determine to a large extent the location of the shipping floor.

Finally, the nature of the product and the processes will affect the solution of the problem. The product may be liquid or solid, light or heavy. The type and location of conveying equipment will be affected by these characteristics. In a monitor type building, used for the manufacture of a given machine, the side bays on the main floor may be used for the production of the heavier and bulkier parts such as the base, frames, and spindles. The bays on the mezzanine floors may be used for the manufacture of the smaller and lighter parts. In the continuous type of manufacturing, the layout of the machines within a department usually is affected directly by the sequence of operations on the parts produced in the department.

**Making the Layout.** Before the layout is made, the probable growth of the business and the maximum volume of production to be handled should be determined by consultation between the sales, production, and statistical executives. The anticipated maximum production of each

item of product should be broken down to get the maximum production for each part.

Certain process information must be obtained before the required amount of equipment can be determined. In the case of a new plant and a new product, the process engineer must process the parts. If the product has been manufactured previously, it is probable that most of this information is available in the process engineer's files. While the nature of this information will vary somewhat with the nature of the manufacturing problem in general, such information is required as the maximum quantity of each part to be manufactured, the operations through which the part must pass, and their sequence; the unit time

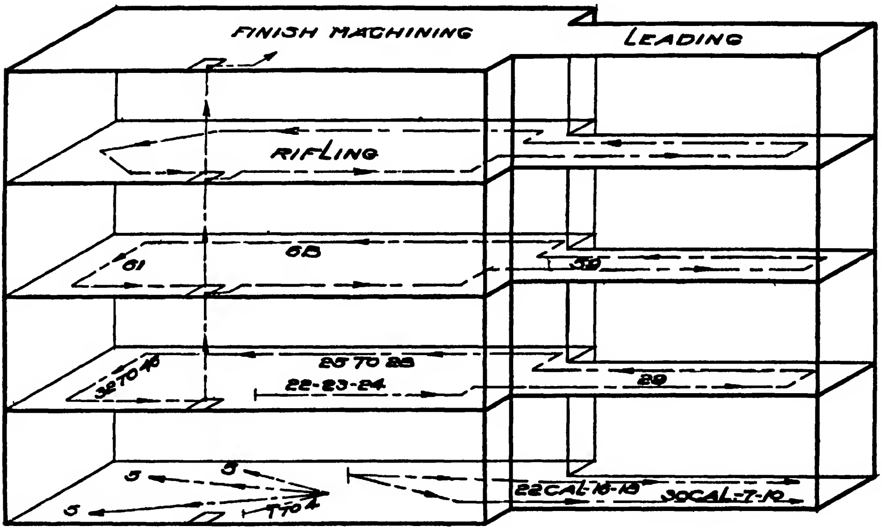


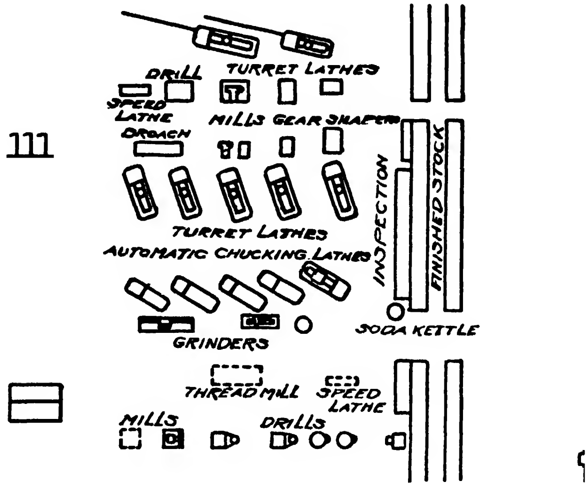

FIG. 1
FLOW SHEET FOR THE BARREL SHOPS OF A MUNITIONS MANUFACTURER

required for each operation; the hours worked per day and the number of days in the working period; the number of shifts and the necessary allowances for scrap and idle time. From this information the number of machine hours per day required for each operation and the number of each type and style of machine can be determined.

The first step in laying out the machinery usually is to make a flow sheet. This is a rough diagram showing the best routing for each part. The general outlines of the factory floor space are shown roughly. Fig. 1 shows a flow sheet of this kind. It aids in working out, tentatively, the best locations of operations and departments.

Templates are drawn to scale on cardboard for each machine. The template represents the actual floor space required for the machine,

and in addition may include that which is necessary for the storage of material at the machine and the efficient operation of the machine by the workman. The templates must be drawn to the same scale as the floor plans. They are placed on the floor plan to conform with the general plan of layout as indicated by the flow sheet. In most cases, the layout of the templates will indicate many changes that must be




*Courtesy—Jones and Lamson Machine Co.*

FIG. 2

Example of a Plant Layout

made in the flow plan. After the templates have been arranged and rearranged to get the best layout of machinery and equipment, the layout is turned over to a draftsman who makes drawings and tracings for each floor and each department. Blue prints are made and turned over to the millwrights for installation.

While this procedure may seem arduous, it is necessary to insure that most economical layout of machinery and equipment which is a prerequisite to economical production.

# CHAPTER IV

## LIGHTING, HEATING, AND VENTILATION

**The Importance of Good Illumination.** Illumination is an important factor in production. A poorly lighted shop presents a gloomy appearance which has a depressing effect on the worker, tending to lower his production. Improper illumination may cause eye strain, which will produce fatigue and further lower the worker's ability to produce. The foreman's problem of supervision is increased. With many classes of work, it is impossible to maintain a proper standard of quality. Interferences to production, due to an excessive amount of scrap or reworked product, are expensive in many ways. Other reasons could be given to show why proper illumination may aid production materially. In some cases, a study of the illumination problem, followed by the introduction of improved methods, has resulted in production increases ranging from 10 to 25 per cent.

A technical consideration of illumination is beyond the scope of this book. Therefore, consideration is confined to the relation of some of the more important aspects to the problems of management.

**Natural Illumination.** During the greater part of the working period, daylight is the principal or only light that is used. For this reason, the problem of natural lighting has directly affected the design and layout of factory buildings. The two principal factors are (1) the intensity and distribution of light, and (2) provision of the maximum amount of light.

**The Intensity and Distribution of Light.** In the average multi-story factory building the intensity of light varies considerably between the sidewalls. In the areas contiguous to the windows there may be a very high intensity, while the interior of the shop may be so dark that it is necessary to burn drop lights at machines most of the time. If clear glass is used in the windows of a standard multi-story building, the floor area within six feet of the east windows may be illuminated with an intensity exceeding five hundred foot candles on clear sunny days.[1] It may drop below one hundred foot candles on cloudy days. The interior of the shop may have an intensity less than two foot candles, despite the high intensity at the windows. The major part of the light has been absorbed by the floor and objects near the windows.

[1] The unit of illumination is the foot candle. It is equivalent to the intensity of light from a standard candle at a distance of one foot.

In general, the interior of the shop ought to have an intensity of at least five foot candles.

The above conditions tend to produce glare. When certain intensely lighted areas are surrounded by areas in which the intensity of light is much less, the eye has difficulty in adjusting itself. If the pupil contracts to shut out excess light from the intense source, it does not admit sufficient light from the less intensely lighted area. If the work is located in this area, the result is poor quality. The reverse condition is just as bad. Such conditions are trying and quickly produce fatigue. As shown in Fig. 3, the curve of illumination across a shop, in the

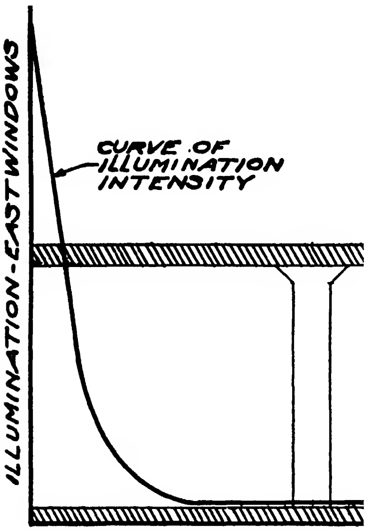
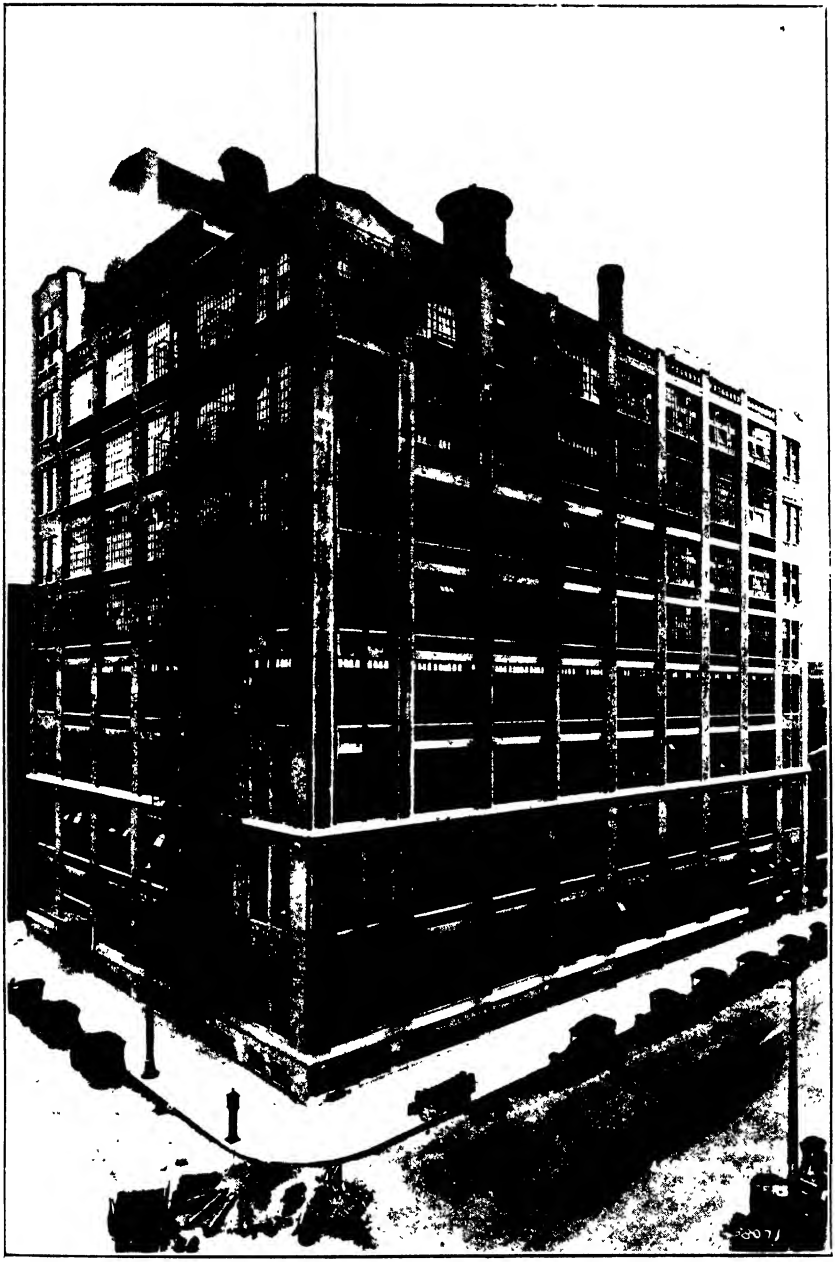



FIG. 3
VARIATION IN ILLUMINATION ACROSS THE SHOP FLOOR

average multi-story building, is roughly a broad-based U. The problem is to flatten this curve as much as possible diffusing and distributing the intense light at the windows evenly over the whole floor area.

The more common solutions for the problem of proper intensity, diffusion and distribution are (1) the use of the proper kind of glass and, (2) the proper orientation of the illuminating devices. A number of kinds of glass are used in connection with natural lighting. Clear glass is the most efficient from the standpoint of light transmission. It has the disadvantage that it admits the light directly, producing adverse conditions that have been described previously. It may be used from the bench level to the level of the workman's head. The loss of a few moments when he glances from his work to objects outside the plant



*Courtesy—Lockwood, Greene & C*

PLATE 6

REINFORCED MULTI-STORY FACTORY BUILDING

does not affect his production seriously. On the contrary, it may aid it by providing a break in the fatigue-producing monotony of his work. Above this, some special type of glass, intended to give better diffusion and distribution, should be used. Prism glass takes the light rays falling on the window at an angle and bends them so that they pass horizontally into the shop. It is considerably more expensive, but it gives a much better distribution of light. Ribbed glass is often used as a compromise. It is less expensive than prism glass and accomplishes the same results, although not to the same extent, when the glass is set so that the ribs run horizontally. It breaks up and diffuses the direct light rays and directs a good proportion of the light into the interior of the shop. It has the disadvantage that it collects dirt and is hard to keep clean. A common practice, and a poor one, is to coat clear glass with white paint. It may eliminate more than 30 per cent of the total light falling on the windows.

The direct rays from the sun form only a small proportion of the total light that finds its way into the interior of the shop. Most of the light is reflected from the sky. For this reason, the variation in light intensity, between clear and cloudy days, is least at the north windows. With multi-story buildings, little or nothing can be done to orient the windows to take advantage of the north light. Single-story buildings and the top floors of multi-story buildings can be equipped with saw-tooth roofs, oriented to the north, affording an evenly distributed and diffused light that is subject to minimum fluctuations due to variations in weather conditions.

**Providing the Maximum Amount of Light.** The effective wall area for natural lighting extends from the bench level to the ceiling. In most plants, not over 75 or 80 per cent of this area is in glass. With daylight construction,[1] it is possible to put almost 100 per cent of this area in glass. The obstruction of light by frames can be reduced to a minimum by using steel framing.

It is not unusual to see a plant with modern window construction, and windowpanes that are so dirty that a large percentage of the natural light is cut out. An efficient janitor service can aid materially in solving the problem of sufficient light.

The treatment of the interior surfaces of the shop affects its illumination. In some cases walls are painted dark brown, in order that dirt will not show. When this is done a large percentage of the light that comes into the shop is absorbed by the walls. It is better to whitewash them and to paint machinery and equipment battleship gray, in order that a maximum percentage of the light that falls on them may be reflected back into the shop.

[1] See p. 28.

In multi-story buildings, low ceilings usually mean poor illumination. More light gets to the center of the shop if there is the greatest practical ratio of ceiling height to floor width. With buildings from 50 to 70 feet wide, the ceilings should be from 12 to 17 feet high.

Where possible, overhead lighting is desirable. The usual means of overhead lighting are (1) ordinary skylights, (2) monitors, and (3) saw-tooth roofs. The first two require relatively inexpensive construction. While the amount of light coming into the shop is greatly increased, they have the disadvantage that unless special glass is used, the direct rays of the sun are admitted which tends to cause glare. The saw-tooth construction though more expensive, is much better. When oriented to the north, a uniform reflected light is admitted evenly over the whole floor. The back surface of each tooth should act as a reflector for the tooth behind it. For this reason, both the interior and exterior surfaces of the saw-tooth should be whitewashed. With the usual saw-tooth construction, the depth of each bay is about 25 feet. The area of the tooth face that is in the glass should be from 30 to 35 per cent of the floor area of the bay. The height of the tooth is governed accordingly.

**Artificial Illumination.** Sometimes, in plants in which the natural illumination is good, the artificial illumination is poor. Yet some artificial illumination may be necessary from 10 to 40 per cent of the working period, depending on the latitude, the season of the year, weather, and natural lighting conditions in the shop. Mr. Roy Palmer of the National Lamp Works [1] states that production tests of improved lighting, for quite different operations in fifteen plants, showed increases in production from 8.5 per cent to 35 per cent. The average increase was 16.28 per cent. He points out that the speed of vision increases steadily as more light is supplied, continuing with intensities of illumination considerably above those which are usually found in the average plant. The relation of this phenomenon to the quantity and quality of production and the accident rate is obvious. At the Columbus plant of the Timken Roller Bearing Company, a production test of illumination was made in the inspection department. The results are given below.

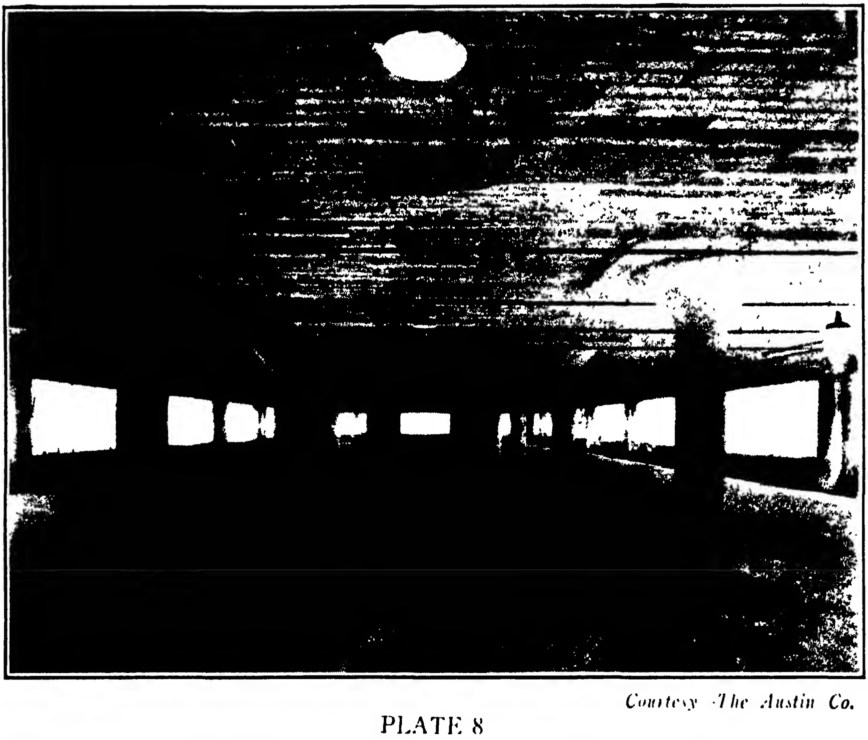
| *Illumination* | *Per cent increase in lighting cost* | *Per cent increase in production* |
|---|---|---|
| 5 foot candles (Old lighting) | 0 | 0 |
| 6 " " | 0.5 | 4.0 |
| 13 " " | 1.3 | 8.0 |
| 20 " " | 2.1 | 12.5 |

[1] How Much Does Light Affect Production? by Roy A. Palmer, *Manufacturing Industries*, October, 1926.

*Courtesy—Lockwood, Greene & Co.*

PLATE 7

Mill Construction



*Courtesy The Austin Co.*

PLATE 8

INTERIOR-REINFORCED CONCRETE INDUSTRIAL BUILDING

The maintenance and operating expenses of a good lighting system are repaid, with good profit, by increased quantity and quality of production, decreased labor turnover, and improved morale in the working force.

**The Requisites of Good Lighting.** The more important requisites of good lighting are (1) an intensity of light, suited to the particular manufacturing conditions, (2) good color, (3) a proper distribution of light, (4) absence of glare, and (5) a steady, uniform production of light.

Insufficient light tends to produce eye strain and fatigue, which affect the quality and quantity of production adversely. Obviously, the requisite intensity of light will vary considerably with manufacturing conditions. In many cases, different intensities of light are required at different points within the same department. In general, the following intensities will be found to be satisfactory.[1]

| *Manufacturing condition* | *Intensity* |
|---|---|
| Storage spaces, aisles and passageways | 1– 3 ft. candles |
| Rough manufacturing and assembling | 4– 8 " " |
| Ordinary " " " | 6–10 " " |
| Fine " " " | 8–12 " " |
| Very fine " " " | 10–20 " " |
| General office | 8–12 " " |
| Drafting room | 12–20 " " |

In some cases, the color of the light may be important. Special lights have been developed for department stores and industries that have occasion to match colors accurately. In some cases, workmen have objected to mercury-vapor lights because they give them a somewhat ghastly appearance. The eye is habituated to the color of daylight. In general, that light which most closely approximates the color of daylight is the best.

The proper distribution of light is always important. The point of work on the machine often requires a higher intensity of illumination than the general work area. In some cases, a particular group of machines may require more intense illumination. The problem is to give these points the requisite illumination without creating sharply contrasting light areas that may produce glare. Its solution depends on the proper adjustment of such factors as the number of lights to be used, their candle-power, location, spacing, height above the plane of work, the type of fixture, and the nature of the work.

The causes and ill effects of glare have been previously noted.[2] Glare has been defined as "any brightness within the field of vision

[1] Further information can be obtained from *Management's Handbook*, the code of lighting of the Bureau of Labor Statistics, the laboratories of the National Lamp Works at Cleveland, and other sources.

[2] See p. [illegible]

which causes or tends to cause discomfort, interference with vision, or eye fatigue."[1] In addition to sharply contrasting areas of illumination, it may be caused by a source of great brilliancy within the field of vision. Glare may be produced even though the eye is not directed at the source of light while at work. Direct and reflected glare may be reduced by adjusting the location and height of the lamps so that there is a wide angle between the eye, the work, and the source of light, by the proper distribution and diffusion of light, and by the proper selection of reflectors and lighting fixtures.

When light flickers or its production is variable, the eye is constantly attempting to adjust itself to a succession of lights and shadows. The condition is one that makes it difficult to do accurate work and is conducive to eye fatigue. For this reason, a steady, uniform production of light is desirable. This requirement is met by the modern means of producing light such as the mercury-vapor lamp, the incandescent lamp, and the Welsbach burner.

The source of light should not discharge impurities into the atmosphere of the shop.[2] This factor should be considered in connection with ventilation if it is desirable to use some type of gaslight because of a cheap gas rate.

**Types of Illumination.** The types of illumination may be classed as (1) general illumination, (2) local illumination, and (3) modifications of the two.

General illumination has to do with the uniform distribution of light over the whole department with an intensity that will satisfy average manufacturing conditions within it. It is accomplished by equally spacing large lighting units. In most cases, the plane of the lights is about one foot below the ceiling level. The spacing of the lighting units is about one and a half times the height of the plane of the lights above the general plane of work. The distance from the wall to the nearest row of lights is about one-half of this distance. To illustrate, if the ceiling is about fifteen feet above the plane of work, the distance between the lighting units should be about twenty-one feet, and the distance of the nearest row of lights from the wall should be about ten and one-half feet.

Local illumination has to do with the provision of a more intense light for certain limited areas within the department. In many cases it is necessary to supplement the general lighting with local lighting at the point of work on the machine. For this purpose a deep-bowled reflector, mounted on a goose-neck, as shown in Plate 12, may be used effectively. Such local illumination is often obtained by using a clear

[1] *Management's Handbook*, p. 340.
[2] See *Industrial Management*, R. H. Landsburgh, p. 137.

light with a shallow reflector suspended by a drop cord from the ceiling. Under such conditions, the light shines directly in the worker's eyes much of the time, producing a condition of glare. When local lighting is used without adequate general lighting, the intensely lighted area at the machine is surrounded by deep shadows. This condition also tends to cause glare.

In some cases, a group of machines may require a higher light intensity. The general lighting scheme must be modified to give this intensity. This type of lighting is known as group lighting.

**Types of Lights.** The types of lights commonly used in industry are (1) mercury-vapor lights, (2) incandescent lights, and (3) gaslights.

In the mercury-vapor lamp, light is produced by an electric arc passing through mercury vapor. It has a bluish-green color that gives the workers and their surroundings a most unnatural and unpleasant appearance. It has the advantage that it does not produce sharp shadows and is frequently used for this reason. The most common type of light is the incandescent electric lamp. When the lighting is properly planned, it is the most satisfactory. In localities where gas is cheap, Welsbach burners may be used. They are efficient and the light has a good color. They have the disadvantage that they tend to vitiate the air.

**Methods of Lighting.**—There are three methods of lighting, (1) indirect, (2) semi-indirect, and (3) direct lighting.

With indirect lighting, the light is reflected by means of opaque reflectors, from the source of light to the ceilings and walls and thence into the room. A large share of the light is absorbed by the ceilings and walls and the cost of illumination is increased accordingly. If the reflectors are allowed to accumulate dirt, there is a further loss of light. It has the advantage that it gives a soft, pleasant, diffused light, and for this reason it is sometimes used in offices.

In semi-indirect lighting, the reflector is a semi-opaque bowl. Part of the light passes through the bowl and part is reflected from the walls and ceilings. A greater percentage of the light from the source reaches the working surfaces, and lighting costs are correspondingly less. This method of lighting is frequently found in offices.

With direct lighting, the greater part of the light passes directly from the source of the light to the working surfaces. Usually a clear light is used with a dished metal reflector. The fixtures are inexpensive and easily cleaned. A greater percentage of light from the source reaches the working surfaces, and the cost of lighting is less than that of the preceding methods. Provided the lights are properly located and the style of reflector is selected with regard to the height of the lights above

the floor, there is little glare. Plate 13 shows a standard reflector. This method of lighting is commonly used in shops.

Obviously, the more acute the angle between the eye, the work and the source of light, the deeper must be the bowl of the reflector to prevent the light from shining directly in the worker's eyes. The following data [1] indicate the relation between the height of the light and the style of reflector:

| *Height above floor* | *Type of reflector* |
|---|---|
| 8 ft. or less | Deep-bowled reflector |
| 8 to 20 ft | Standard dish-bowled reflector |
| Above 20 ft | Flat, polished, steel disk |

**Analyzing Lighting Conditions.** Only sufficient information on industrial lighting has been given to bring out its importance and to enable the executive to recognize poor lighting conditions. Any complete analysis involves technical details beyond the scope of this book. It can be made satisfactorily only by an illumination engineer.

**Heating and Ventilating.** Proper shop heating and ventilating also has an important relation to the quantity and quality of production. In winter, poor air conditioning and ventilating may cause irregular attendance, due to sickness and colds. In summer excessive heat and humidity may interfere with production. In some cases it may be necessary to establish and maintain standard air conditions before certain processes can be carried on satisfactorily. Too great humidity may cause materials and machinery to deteriorate rapidly. Varying temperatures make it difficult to keep fine machinery in adjustment. Proper air conditions directly affect the comfort of the worker and his ability to produce. Many industries, such as food packing, textiles, and wood working, have important air-conditioning problems.

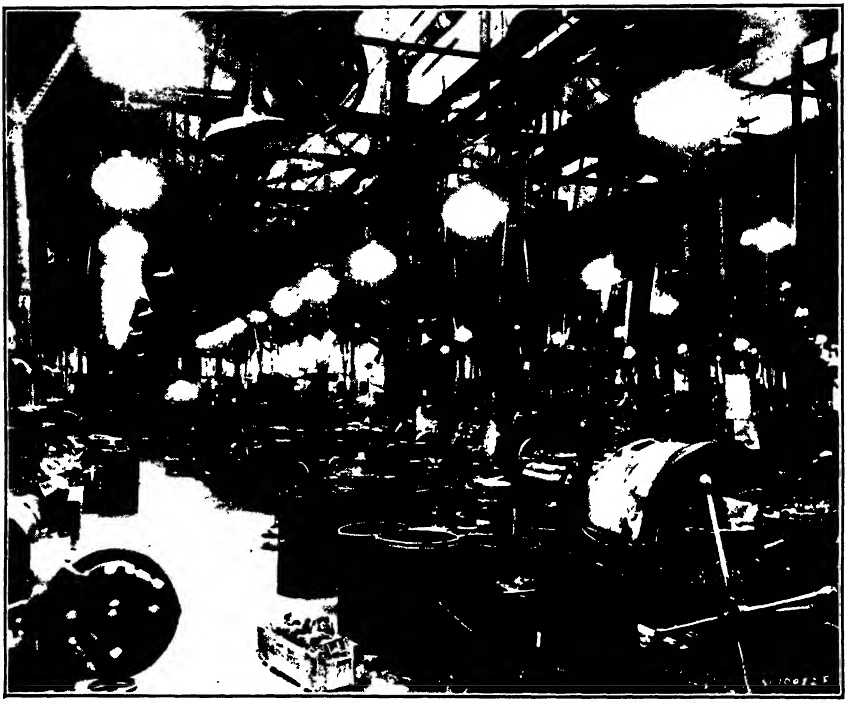
The quantity of air required, its temperature, and humidity depend to a large extent on manufacturing conditions. In general, 2,000 to 3,000 cu. ft. of air per person per hour, having a relative humidity of 60 per cent and a temperature of 68 degrees Fahrenheit, are satisfactory.

[1] Landsburgh's *Industrial Management*, p. 145.

*Courtesy—National Lamp Works.*

PLATE 9

VIEW OF A SHOP BEFORE INSTALLATION OF A GOOD LIGHTING SYSTEM



*Courtesy National Lamp Works.*

PLATE 10

SAME SHOP AFTER INSTALLATION OF GOOD LIGHTING SYSTEM

# CHAPTER V

## ORGANIZATION

**The Meaning of Organization.** A clear distinction should be drawn between system and organization. The system is the normal routine by which the operations of the business are carried on and controlled. When methods are developed which will enable one at any time to know how much of a given item of material is available for future orders, a system has been developed. An organization is a group of persons cooperating to a common end. In industry it refers to the relations of one component group of the personnel to another with regard to the proper functioning of the whole in the operation of the system. When certain departments are set up for the administration of certain management functions and lines of authority for their control are determined, organization is developed.

**Fundamental Considerations.** There are certain fundamental considerations underlying good organization. In developing the organization, consideration should be given to (1) the fundamental functions to be performed and their relation to one another, (2) the proper division of responsibility, (3) the definite location of responsibility, (4) the proper functioning of the system, (5) the flexibility of the organization, (6) provision for future growth, (7) personal characteristics and abilities, (8) the creation of an ideal, (9) the quality of the leadership.

In developing the organization, the various functions to be performed, their relations to one another, and their relative importance should be studied. Such study is a necessary prerequisite for the development of the various organization units and their relations to one another in such a manner that they may cooperate to the best advantage in the performance of these functions. Failure to develop the organization with regard to functional relationships usually results in an illogical growth of organization units. Its effectiveness is reduced due to the fact that improper functional relationships make it difficult to coordinate to their activities. Usually, authority and responsibility are not delegated in a rational manner with the result that there is an increasing number of executives reporting to the chief coordinating executive. The increasing burden of direction and supervision tends to reduce his effectiveness. The organization becomes unwieldy and slows down. Furthermore, where functional relationships have been neg-

lected, it is often difficult to define and limit the scope of each executive's authority and the field of his activities. There is likely to be an overlapping of authority, jealousy, and conflict where there should be friendly, enthusiastic cooperation.

The division of responsibility should be such that adequate supervision can be given to the various units of the organization. It is obvious that a general foreman should not be given the supervision of a number of widely separated shops, unless there are considerations peculiar to the situation which make it imperative. The amount of time spent between shops and the difficulty in locating him quickly would make their supervision difficult. In order that adequate supervision may be given, executives should not be overloaded. Furthermore, in assigning departments to an executive, those departments should be grouped under his supervision whose functions and activities are complementary to one another. The development of the organization in accordance with this consideration facilitates the development of specialists in the various fields of management. Responsibility and authority should be delegated with regard to the kind and importance of the functions to be performed. Responsibility can never be delegated satisfactorily unless sufficient authority for its proper discharge is granted.

In the investigation of an organization, it is not uncommon to find that many employees, and perhaps some executives, have only a hazy idea of their responsibilities and the lines of authority to and from their jobs. Under such conditions, there may be excessive shifting of responsibility. Every executive and employee should know definitely the functions that he must administer, the duties that he must perform, and the results that are expected of him. If he knows that he will be held strictly accountable for these results, he will give his best efforts.

A consideration which is closely allied to the proper division and location of responsibility is the development of the organization with regard to the proper functioning of the system. In some organizations, separate departments must be set up for the performance of a given function. In others, a combination of functions is possible with satisfactory results. However, the relation of departments to one another should facilitate the operation of the system. The development of the organization in this respect is different for each company. For example, the functions of procurement by speculative purchase and procurement by routine purchase in some cases are administered by separate departments under some general purchase executive. In other cases, by a single department. In any event, the purchase organization

must be such that the normal routine for purchase control can operate smoothly.

The efficiency of operation is increased if the organization has flexibility. At certain times, the production-planning organization may be working under great pressure. It may be desirable to expand it, setting up distinct units for the administration of certain planning functions. When a period of dull business arrives, the organization should be able to contract easily and quickly without loss of administrative efficiency. Similarly, it should be possible to expand or subdivide organization units, as the business grows, without loss of coordination and effectiveness. The organization should be built with regard to the future as well as the present.

In the division and location of responsibility, consideration should be given to the personal element. Obviously, department heads should be selected on the basis of experience and ability. In actual practice, the selection is often affected by personality, social or family connections, factions in the organization, the aggressive desire of certain executives to extend their authority, and similar influences. Unless checked, they may result in considerable loss of organization effectiveness. It is not uncommon to find an executive whose aggressive personality has enabled him to override other executives of equal or greater ability and to gather a large but motley array of organization units under his supervision. Of course, it may be desirable, in some instances, to divide responsibility in such a manner that the greatest use is made of certain executives having unusual ability and experience. Finally, the design of the organization, with regard to its future growth, is affected by personal characteristics and abilities. An executive may have sufficient ability and experience for present problems, but little adaptability and capacity for growth with the organization.

The effectiveness of the organization depends to a large extent on the development of an *esprit de corps*. This, in turn, depends on the creation of an ideal for which the whole organization is striving. It may be the manufacture of a product of unquestionable quality, the maintenance of a reputation for prompt deliveries, or any other ideal in which the organization can have a common interest.

The quality of the leadership is a factor, limiting the effectiveness of the organization. The difference between good and poor leadership is very often the difference between success and failure. Sometimes a poorly designed organization, using mediocre methods, enjoys considerable success because it is fortunate in having experienced principal executives whose personalities, tact, and abilities gain for them the loyal, enthusiastic cooperation of the whole organization.

Too much stress cannot be laid on good organization. It has been said that the organization is the engine that drives the business. If properly designed and tuned up, it is an important factor in the success of the enterprise.

**Types of Organization.** There are five organization types, (1) the military or line, (2) the line and staff, (3) the functional, (4) the departmental, and (5) the committee forms of organization. In reading the following discussion of these types, it should be remembered that they rarely exist in their purest form. Most organizations are a cross of two or more of those organization structures which we have chosen to designate as organization types.

FIG. 4
A Military or Line Organization

The military or, as it is often called, line type of organization is the logical outgrowth of the relations of master and journeyman. As the small business grows, and with it the organization, it becomes necessary for the owner-manager to delegate more and more responsibilities to subordinates. However, it is natural for him to retain as close supervision of the discharge of these responsibilities as possible. As a result, the military type of organization is characterized by a flow of ideas and orders from the head of the organization to those who are charged with their ultimate execution. In the industrial military organization, these orders impinge on the foreman in most cases. He is responsible for the performance of a wide range of duties which call for widely differing abilities. It is a common expression that the foreman is the key man in industry. It is difficult to obtain minor executives who

have all of these abilities. Consequently there is the complaint that it is difficult to get good department heads.

Dr. Taylor felt that the great load that is placed on the foreman in the average plant is one of the greatest deterrents to the attainment of high efficiency. His list of duties which the military type of foreman must perform indicates why many important functions are not handled properly under this type of organization. The duties and qualifications of the military type foreman, as Taylor summarized them, are: [1]

(1) He must be a good machinist.
(2) He must be able to read drawings readily.
(3) He must plan the work of his department and see that it is properly prepared.
(4) He must see that each man keeps his machine clean and in good order.
(5) He must see that each man turns out work of the proper quality.
He must see that the men work steadily and fast.
He must see that the work flows through the work centers in the proper sequence.
(8) He must in a general way supervise time-keeping and rate-setting.
(9) He must maintain discipline and adjust wages.

In addition, much of the work of maintenance falls on him in many plants.

The military type of organization has the advantage that the lines of authority are fixed and definite. Responsibility is easily placed. In small organizations, in which the division of responsibility need not be great, the military form of organization may give satisfactory results. In such cases, functions are not highly developed, organization units are small, methods are simple, and the management is closely in touch with shop conditions.

**The Line and Staff Organization.** As the business grows, the burden on the line organization becomes greater. The administration of the various functions of management becomes a more complex problem. The proper development of these functions calls for an increasingly greater range of ability and specialized knowledge in the individual executives, which is hard to find. Eventually they must be relieved from some of this increased load. Otherwise there will be a serious loss of efficiency, due to the tendency of the organization to break down. The exact point at which this tendency becomes noticeable depends on a

[1] *Shop Management*, by Frederick W. Taylor, p. 96.

number of factors, such as the personality and ability of the chief executive, the nature of the product and manufacturing conditions.

Recognition of the need for specialization naturally leads to the development of the line-and-staff type of organization. It is characterized by the creation of specialized or staff departments for the administration and development of certain functions. In most large concerns, the engineering functions, once performed by the line organization, are handled today by an engineering department. Until recent years the problems of labor relations were handled by the line executives, as they arose, in the manner which best appealed to the particular line executive. In the more progressive concerns they are

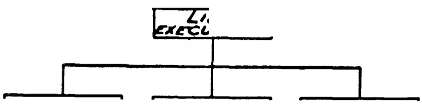


FIG. 5
A Line and Staff Organization

now handled by specialists in the personnel department. In theory, a staff department has complete authority in its particular field in so far as policies and methods are concerned. In practice this authority is usually modified by conference with the line executives to insure cooperation and proper coordination of effort. Furthermore, the staff department must get the approval of some higher coordinating executive before issuing to the line organization orders relating to new policies or methods. The supervision of all activities of the operating departments remains in the line organization. The effectiveness of the organization is greatly increased by the administration by specialists of the important functions of production, which have become too large or complex to be handled effectively by the line organization. As a result, the line-and-staff type is quite common.

**The Relation of Staff Indirect Expense to Production.** It may be objected that staff departments require too much indirect or "nonproductive" labor. Most executives watch closely the expense of such labor. Obviously, they are justified in opposing unwarranted additions to the payroll. Unfortunately, they often fail to distinguish clearly between what is warranted and what is not. They will sometimes approve the hiring of additional operatives to get more production, and disapprove the hiring of clerks, for the same purpose. Yet the staff departments, by facilitating production and removing interferences to it, may be able to increase production far more.

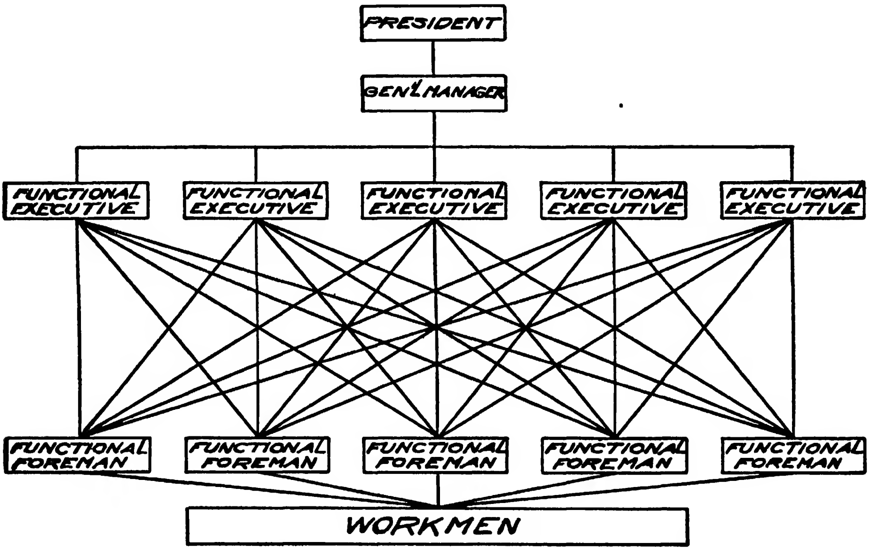



FIG. 6
A FUNCTIONAL ORGANIZATION

**The Functional Organization.** In the functional form of organization, specialization is carried much farther. Each of the important functions of management is administered by specialists. In order that the organization may get the greatest benefit from the specialized knowledge of these functional executives, they are given full authority over operations in so far as their functions are concerned.

In the completely functionalized organization there is no line organization. The employee must look to a number of executives for instructions. This may impair discipline by permitting him to play off one executive against another. Furthermore, it is difficult to draw sharp dividing lines between many of the functions of management,

and accordingly there is danger of conflict of authority between the various functional executives.

In the small organization it is necessary to combine functions in the interests of economy so that many of the advantages of functionalization are lost. As the size of the organization decreases, the necessity for combining functions increases, and as a result the form of organization tends toward the military form. However, in developing methods for the small organization, functions should be recognized clearly and provision should be made for their proper administration.

There are many cases where functionalization has been developed extensively, but there are almost no pure, functional organizations. In most cases complete functionalization is prevented by the great increase in indirect expense involved and the fact that the division of responsibility results in inefficiency if carried beyond a certain point.

**The Taylor Functional Organization.** Dr. Taylor's shop organization was a pioneer attempt to functionalize shop management. As previously stated,[1] he felt that the military type of foreman has so many and varied duties that it is impossible for him to perform all of them efficiently. To avoid this situation, he developed a shop organization which divided the various functions of the military-type foreman among eight functional foremen.[2] The executives are listed below, with a brief statement of their duties:

(1) *The Order of Work and Route Clerk* planned the work, routed it through the shop, made schedules for various jobs, and determined the order of work. The development of this function has resulted in the modern planning department.

(2) *The Instruction-card Clerk* made out instruction cards for the workmen. Instead of leaving to the judgment of the workman the selection of the tools to be used, the speed and feed of the machine, and other problems relating to the performance of the operation, the best method of performing it was determined by scientific analysis and recorded on the instruction card.

(3) *The Time and Cost Clerk* secured the basic information for the cost and production records. He issued and received the workman's job tickets, figured job costs, and performed similar duties. Today, the cost function, in most progressive concerns, is administered by a staff organization, the cost department. Much credit for its development must be given to Taylor's recognition of the importance of accurate costs.

(4) *The Gang Boss* was a shop functional foreman. His function was preparation for production. He moved work to the machine, set

[1] See p. 45.

[2] *Shop Management*, by Frederick W. Taylor, p. 100.

it properly in the machine, and moved it to the inspector when the job was completed. He saw that tools and equipment were at hand and that there was work ahead of each operator at all times. Taylor was among the first to recognize the importance of the preparation function in management.

(5) *The Speed Boss* was essentially a teacher who instructed the workmen in the best method of performing the operation as shown by the instruction card. In many modern organizations, the principle of increasing production by increasing the worker's skill content is applied through a training division in the personnel department.

(6) *The Inspector* was responsible for the quality of the work.

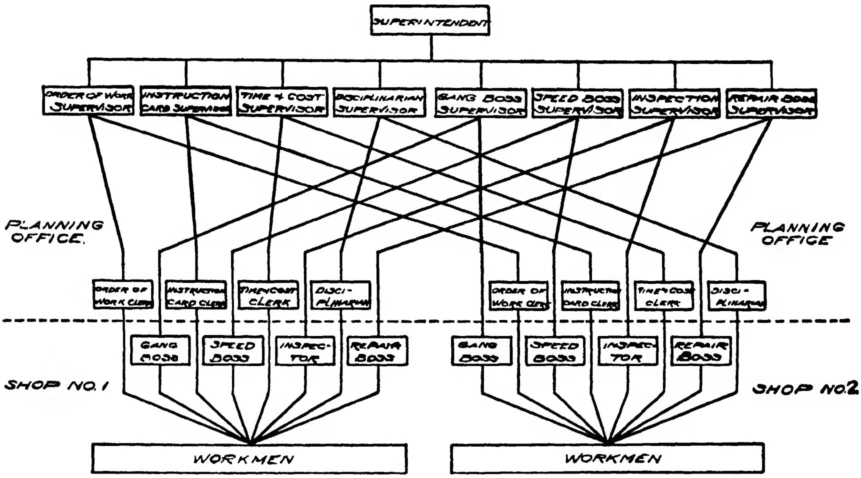



FIG. 7
THE TAYLOR ORGANIZATION

(7) *The Repair Boss* had charge of repairs to machinery and equipment. Under the military form of organization, the foreman is often responsible for such work. The function of maintaining the physical efficiency of plant and equipment has been developed highly in many plants and is administered by a staff department, known usually as the maintenance department.

(8) *The Disciplinarian* administered the personnel functions in the shop. In addition, the Taylor plan of organization provided for an employee's mutual benefit association, an employment bureau, and other personnel activities which have since been combined and developed into the modern personnel department.

In order to insure coordination between the efforts of the various functional foremen, general functional foremen or functional supervisors were set over them. The supervisors should be broad-gauged

executives, capable of adjusting differences between functional foremen with a minimum of friction.

Taylor's organization was developed in the metal-working industries, and as a result could not be applied to other industries without some modifications. For example, in industries where there is no well-developed engineering department, such as the clothing industry, it would be necessary to add another functional executive who might be called the specification clerk. His function would be to make the specifications for material and product, work up such basic information as is necessary for the proper control of production, and in general perform those engineering functions which are prerequisite to production control.

The Taylor form of organization in its entirety has not been introduced in American industry to any great extent. In part, this is due to the fact that it is difficult to convince executives that the savings from functionalization can offset the increased indirect shop expense. Modern organization methods make it possible to administer functions effectively at less expense. Even if this were not so, it could not be introduced in many industries without numerous changes. The characteristics of the industry affect the development of the organization materially. Finally, the Taylor division of functions is adapted chiefly to shop conditions. It cannot be applied readily to the other units of the organization, as, for example, the purchasing department.

The Taylor functional organization is interesting to students of management because it was the first to give clear-cut recognition to many important functions of management. It focused the attention of the more progressive managers on them. The development of many important organization and management methods can be traced to it.

**The Otterson Organization.** An interesting development of a functional organization was made at the Winchester Repeating Arms Co., by Mr. John E. Otterson during the World War. In order to meet the war needs for munitions, the company expanded its personnel approximately 450 per cent until at the peak of its activities, it was employing about 22,000 employees. This great expansion, coupled with the difficulties incident to manufacturing under war conditions, changed the character of the management problems to such an extent that it became necessary to change the form of organization to one which was largely functional.

Management was divided into five basic functions, (1) planning, (2) preparation, (3) scheduling, (4) production, (5) inspection. Planning determines what shall be done and how it shall be accomplished. Scheduling determines when it shall be done. Preparation determines whether the job can be done in accordance with the plans

and schedules, and anticipates interferences to production. Production is responsible for the actual accomplishment. Inspection determines the quality of the results. Fig. 22 is a sketch of the resulting organization. Each of the five functional supervisors had complete charge of those phases of manufacturing within his particular field. In the shop organization, the functional overseers reported to their functional supervisors in so far as the execution of their functions was concerned, but reported to the foreman in all matters of discipline and the routine operation of the shop. By this arrangement, the foreman's authority was not impaired. In fact, the overseers usually looked to him as their immediate superior. The advantages of functionalization were gained without loss of coordination or serious conflicts of authority.

FIG. 8
THE OTTERSON ORGANIZATION

There was a large number of shops, many of which had large payrolls. In shops which were not large enough to support the complete organization, the clerical work of the planning and scheduling overseers, or the work of the preparation and production overseers, could be combined.

In some respects the Otterson shop organization is similar to the Taylor organization. The preparation overseer performs duties which are similar to those of the gang boss. The production overseer performs the duties of the speed boss and acts as an assistant foreman. The planning and scheduling overseers perform many of the duties of the order-of-work clerk and time-and-cost clerk. The inspectors perform practically the same duties in both organizations. The other functions performed by the Taylor functional foremen are handled by

staff departments. The use of functional supervisors is similar to Taylor's use of general functional foremen.

The Otterson organization is based on a logical division of the functions of management. It can be applied to other than the shop departments more easily than can the Taylor organization. Furthermore, the functions can be combined to meet the needs of the small plant more readily.

**The Sub-departmental Type.** The recognition of the fact that the average military foreman is overloaded has led, in some instances, to the development of a type of organization which may be termed the "sub-departmental" form. Under this plan a shop department is divided into a number of small sub-departments. A sub-foreman or "straw boss" is placed in charge of each sub-department. If the department had a large group of production milling machines and a group of pro-

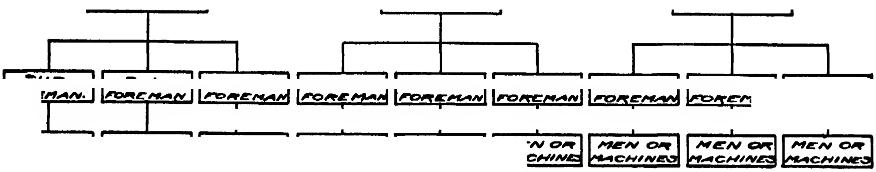



FIG. 9
THE SUB-DEPARTMENTAL ORGANIZATION

filers, a straw boss might be placed over the milling machines and another over the profilers. For these small groups of machines, the straw bosses would perform, under the general supervision of the foreman, all of the functions of shop management which are usually performed by the foreman for the department as a whole. In this manner the foreman is relieved of many of the details which usually take up his time.

The sub-departmental organization, theoretically, is weaker than the functional form in that it assumes that sub-foremen can be obtained who are capable of performing efficiently all of the functions of shop management for their group of machines. Yet, one of the common complaints in industry is that it is difficult to obtain competent department foremen. It is true that it is easier to perform the various functions of shop management for a small group of machines than it is to perform the same functions for the department as a whole. To some extent, such an organization violates the more modern conception that

the real job of the foreman is that of a leader whose important function is to maintain the efficiency of his shop by maintaining morale, instructing his men in the best production methods, supervising production and removing interferences to it.

The sub-departmental organization is based on a mechanical rather than a managerial functionalization. It is an improvement over the military type in so far as it takes part of the load from the foreman. It tends to produce specialists in the operation of a particular type of machine or the production of a particular class of work, while the functional organization produces specialists in the performance of a given function of management. As a result, these straw-bosses become expert in setting up and operating their machines to get the maximum production out of them. Their specialized experience often enables them to make suggestions regarding changes in the method of processing or handling work which result in considerable increases in production. In many instances, the sub-departmental form of shop organization has been introduced with good results.

**Committee Organization.** The committee form of organization is based on the idea that the best policies are made by the common counsel of those affected; that policies which have been formed by such counsel are more likely to receive the support of those who must put them into effect, and as a result have greater chances of success. In connection with the administration of important management functions, there is a pooling of executive experience and ability. To some extent these advantages are offset by certain disadvantages. Committees are often slow to act because of extended discussions, sometimes futile or irrelevant. Many times, the opportunity for debate is too tempting. Furthermore, committees cannot meet often enough to permit the handling of details without taking too much of the executives' time from their regular duties. For this reason their work is usually confined to considerations of the broader problems of management in their particular fields. They are usually legislative, judicial, or advisory; rarely executive. There is often a tendency for one or two individuals with strong personalities to dominate the committee. As a result, the policies of the committee are not the common counsel of all of the members, but rather the opinions of the one or two who dominate.

The committees usually consist of a chairman, secretary, and various members appointed by the management. The chairman should be picked not only for his knowledge of the field, but also for his ability to get things done in meeting; in other words, to prevent the somewhat irrelevant debates which often develop. In addition to keeping the minutes of the meetings, the secretary transmits the policies adopted

by the committee to the proper authority for approval. In some cases he may follow up their application and report developments to the committee.

The committee system is always developed in connection with and is complementary to some other form of organization. The more common committees are the production committee, the product committee, the materials committee, the foremen's committee, the shop committee, and the routines committee.

The production committee determines what shall be made and sold, and when. It is found chiefly in those concerns whose products for the most part are standard and who have a sales or statistical organization which can forecast probable demand with reasonable accuracy. The natural tendency of the sales department is to give those products which have the least sales resistance a larger place in the sales program. If one product uses considerably more of a given type of labor or equipment than another, this tendency may result in an unbalanced production program, certain departments working overtime while others are working part time, and increased manufacturing costs On the other hand, the manufacturing department wishes to manufacture those items which can be produced most easily, at least cost. In many cases they may not meet consumer demand satisfactorily. The production committee must find the happy medium and formulate a well-balanced sales and production program. The committee is usually composed of representatives of the sales, production, engineering, and financial organizations.

The product committee determines what the product shall be. It considers requests for changes in the design of existing products or the introduction of new products. Such requests may come from the sales, production or engineering organization, or from the customer. They bring up problems which affect sales, production, engineering, purchasing, and finance, such as the extent to which the need for the new item is already covered by some other item, the amount and kind of equipment necessary to produce it, the ability of the company to finance the proposition, and many others. In some cases, the committee may pass on methods for the production of the product and the maintenance of its quality, when they involve considerable expenditures. The committee is composed of such executives as the sales manager, the treasurer, the production manager, the chief engineer, and the purchasing agent.

The materials committee controls the company's inventory. It is interested in the execution of the purchase program, the determination of maximum ordering quantities and minimum ordering points below which the inventory of a given item should not drop without reorder-

ing, the standardization of materials, the development of efficient methods of material control, and similar problems. The committee is composed of such executives as the materials superintendent, the purchasing agent, the production manager, the chief engineer, and probably a representative of the financial organization.

The foremen's committee is relatively common in American industry. It is intended to furnish a forum in which the foremen can discuss their problems, to provide a means for making recommendations to the management regarding changes in shop methods or conditions. Obviously, a recommendation from the foremen's committee will carry greater weight than the same recommendation from an individual foreman. Furthermore, the committee offers an opportunity to iron out individual differences which arise in the course of the day's work. Such differences sometimes lead to personal antagonism and lack of cooperation between foremen which is not conducive to maximum production.

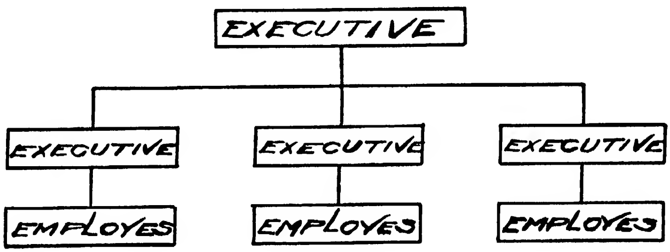



FIG. 10
THE INVERTED TREE CHART

The shop committee is composed of representatives of the employees, elected by and from their own number, who meet with or without representatives of the management for the purpose of making recommendations to the management regarding wages and working conditions and such other matters that come within the scope of the committee. It will be discussed later under employee representation.

The routines committee probably is less common than any of the preceding committees. It is concerned chiefly with the development and standardization of methods for handling the routine management problems.

**The Organization Chart.** The organization chart should be a management tool which can be used constantly in studying and improving the organization. It should be so clear that any member of the organization can understand readily the division of responsibility, the lines of authority, and the relation of one department to another. It should

be inexpensive and such that it can be easily changed as the organization changes. The four common types of organization charts are the inverted tree chart, the circular chart, the pyramid chart, and the horizontal line chart.

The inverted tree chart, so called from its shape, is a very common type. The various organization units are represented by rectangles in which the title of the unit appears, sometimes with a brief statement of its functions. The lines connecting the different squares show the flow of authority. Such a chart is relatively expensive and must be redrawn, traced, and blue-printed if organization changes of any extent

EXECUTIVE

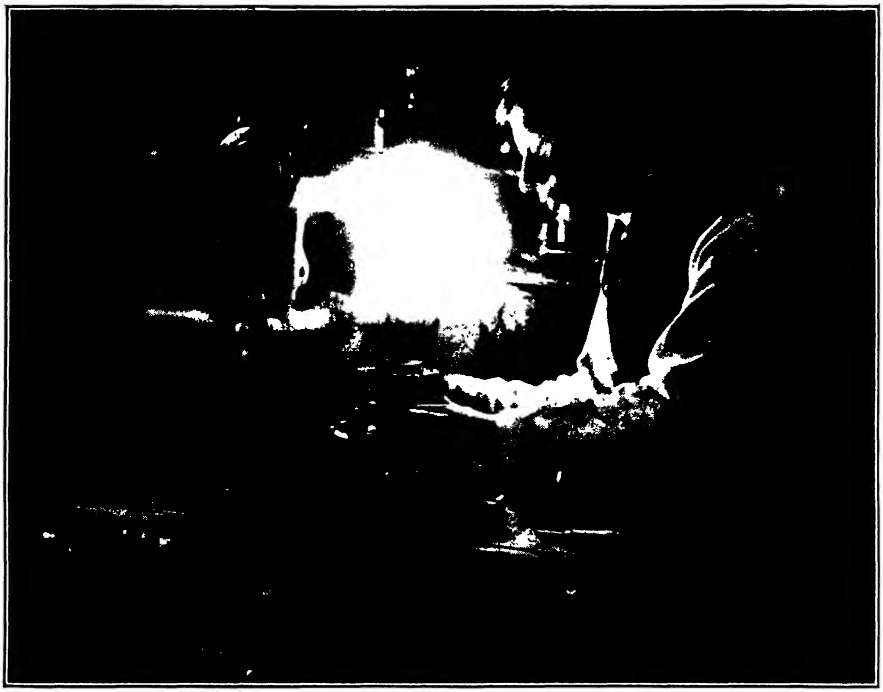
| Department | Department | Department | Department |
|---|---|---|---|
| Executive | Executive | Executive | Executive |
| Functions | Functions | Functions | Functions |
| Duties | Duties | duties | duties |
| Personnel | Personnel | Personnel | Personnel |
| Sub-executive | Sub-executive | Sub-executive | Sub-executive |
| Fucntions | Functions | Functions | Functions |
| Duties | Duties | Duties | Duties |
| Personnel | Personnel | Personnel | Personnel |
| Sub-executive | Sub-executive | Sub-executive | Sub-executive |
| Functions | Functions | Functions | Functions |
| Duties | Duties | Duties | Duties |
| Personnel | Personnel | Personnel | Personnel |

FIG. 11
THE PYRAMID CHART

occur. As a result it is difficult to keep up to date in a rapidly developing organization. However, it gives a graphic representation of the organization which is easily understood.

The circular chart is based on the idea of a radiation of authority from some central source of authority in the organization. It presents an attractive appearance, but is even more expensive to make and difficult to change. Furthermore, it is more difficult to read and understand.

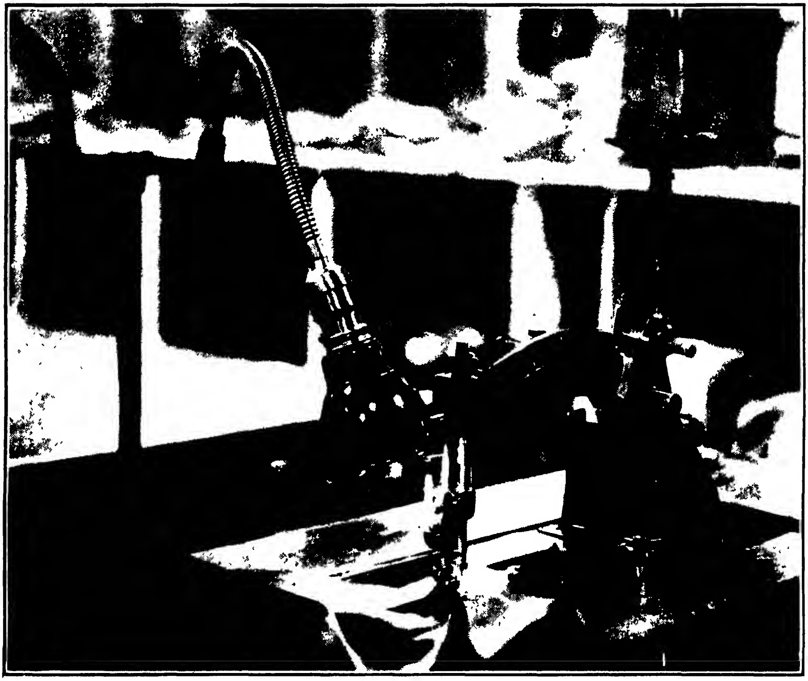
A type of organization chart, used by the National Cash Register Company, may be termed a pyramid chart. Underneath the pyramidal top and supporting it, are a number of columns representing the principal organization units. In each column, the functions of the unit, its chief executive, and the executives and departments reporting to him may be shown. Similar charts can be made for each of these depart-



*Courtesy National Lamp Works.*

PLATE 11

GLARE RESULTING FROM POOR LOCAL ILLUMINATION



*Courtesy National Lamp Works*

PLATE 12

'LED REFLECTOR FOR LOCAL ILLUMINATION

ments in as great detail as may be necessary. If made on 8½ x 11 inch typewriter paper, the charts can be typed and bound conveniently in a loose-leaf binder. In this form they can be made and altered cheaply and quickly. They contain more information of value in analyzing the organization and are sufficiently graphic so that the relations of the various organization units can be easily understood.

| | | |
|---|---|---|
| | Purchasing Agent<br>Mr.Johnson Morgan,(8). | In charge of the purchase of all materials and supplies. |
| | Balance Of Stores Clerk<br>Mr.D.C.Wightman | Responsible for the Clerical control of inventories. In charge of the stores ledgers.<br>Ledger Clerks ----3 |
| Materials Manager<br>Mr.H.C.Williams | ores Superintendent<br>Mr. H.W.Clapsaddle,(7). | In charge of the receipt,storage and movement of raw and worked materials. |
| | alvage Foreman<br>Mr.H.L.Smith | Responsible for the reclamation and disposition of scrap and waste material.<br>Sorters --------- 2<br>Mach. Operators-- 5<br>Laborers -------- 2 |
| | Secretary to the Manager:<br>Miss R.D.Jones | In charge of the Material Manager's office.<br>Clerks ---------- 2 |

FIG. 12
A HORIZONTAL-LINE CHART

The horizontal-line chart is the most practical form of organization chart. It is typed on 8½ x 11 inch typewriter paper. It consists of three columns. In the first column appears the organization head; in the second the names and titles of those executives reporting immediately to him; in the third, a brief statement of the duties and functions of these executives. There is a separate sheet for each division

and subdivision of the organization. These sheets are bound in a folder in the order in which the organization units are related to one another. In Fig. 12, the number (8) under the purchasing agent, refers to page 8 of the folder, on which his organization is found in detail. In addition, to being inexpensive and easily changed, it is possible to get more organization data on this type of chart than on the preceding types. The names of department heads and the personnel of their departments can be shown. In the illustration, it will be seen that the balance-of-stores clerk has three ledger clerks under him. A change in the department head necessitates only retyping one or two sheets. The charts are sufficiently graphical so that the division and location of responsibility and the relation of the organization units can be understood readily.

The organization chart gives a graphical analysis of the relations of the divisions and subdivisions of the organization and the functions which they perform. It facilitates the study of the factors in organization as they affect the company, and aids the logical development of the organization. In so doing it minimizes the effects of favoritism and aggressive personality. It furnishes a permanent record of the growth of the organization, further assuring its orderly development. Finally, the executives and employees have a clearer conception of their relations to one another which tends to reduce misunderstanding, friction, and lack of cooperation.

**Executive Nomenclature.** In discussions of organization, such terms as high executives, major executives, minor executives, do not always have the same meaning when used by different authors. For the purposes of this book, the higher executives are those general officers of the company whose chief function is to interpret the policies of the board of directors to the organization. Usually their offices are established by the charter of the company. In most cases the higher executives are the president, treasurer, and secretary of the company. The managing executives are those executives who are responsible for the administration of one or more of the major functions of the business, and who determine policies governing their performance, subject to the approval of the higher executives. Examples of such executives are the vice-presidents in charge of sales or production in many large corporations. The major executives are those executives who are engaged in the determination of policies and methods in connection with the performance of some specific function, subject usually to the approval of some managing executive. The chief engineer, the production manager, the personnel director, and similar executives usually fall in this class. The minor executives are concerned chiefly with the

execution of orders issued by the previous classes of executives. Foremen and chiefs of sections are examples. There are no sharp dividing lines between the different classes of executives. In some cases the duties of an executive are such that he may be placed in two different classes.

# CHAPTER VI

## THE INDUSTRIAL ORGANIZATION

**The General Functions of the Industrial Organization.** For the most part, the functions of the industrial organization can be classified in three general groups; those functions which are concerned chiefly with (1) the production of the company's products, (2) their distribution, and (3) the financing of production and distribution. In general, they are administered by the production, sales, and financial organizations, respectively. The organization shown in Fig. 13 is

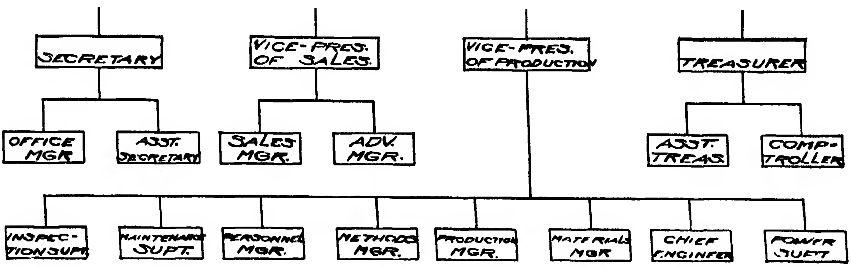



FIG. 13
AN INDUSTRIAL ORGANIZATION

based largely on the classification of functions given above. It is not intended to be an ideal form for general adoption, nor is it implied that most large industrials use this form. As stated previously, the organization for a given concern must be developed with regard for its particular problems. Furthermore, functions could not be specialized to the same extent in the small concern. In a large organization, an executive may be specialized in the administration of one function or even a phase of it. In the small organization, it may be necessary to have him administer a number of functions in order to keep down the indirect expense to a figure which the business can support. It is helpful to study the large organization because the various functions of management may be viewed in detail, much as light is passed through a prism in order that its elements may be studied. The organization in

Fig. 13 emphasizes the important functions in factory management and furnishes a convenient basis for their study.

Before examining in detail the units of the organization and the methods which they use in performing their functions, their work will be surveyed briefly to get an impression of the organization as a whole.

**The Sales Department.** The sales department is concerned with stimulating and developing the sales of the company's products, to the end that a satisfactory volume of sales may be obtained at a reasonable cost of distribution. While it has no jurisdiction over the function of production, it is interested in the attainment of minimum production costs consistent with the required standards of quality, because the price at which most products can be sold directly affects the ease with which they can be distributed.

The head of the sales organization in large concerns is often designated as the vice-president in charge of sales. His work is such that he may be classed as a managing executive. He directs and coordinates the sales and advertising organizations. He cooperates with the finance and production organizations in the planning of sales and production. In addition to a technical knowledge of markets and selling, he must have the qualities of leadership, executive ability, vision, and enthusiasm to a high degree. Personal inspiration often plays a great part in the work of the sales force. The results obtained by the salesmen in the field are affected in no small degree by the encouragement, cooperation, and advice which they receive from the home office, and their confidence in their chief executive.

Under the vice-president, there may be a sales manager who is directly in charge of the sales department. He may be classed as a major executive. Such problems as the determination of sales schedules, the analysis of the product from the standpoint of its selling qualities, changing consumer demand, deliveries, seasonal variations in demand, and similar problems come within his field. The sales force, the sales engineering section, and the sales office organization may be under his supervision.

The work of the sales-engineering section may be subdivided into the work of sales promotion, sales planning, and sales analysis. The development of this section in modern organizations is an example of the tendency to introduce methods of scientific analysis in the solution of management problems. The sales-promotion group is engaged in the study of those factors affecting the growth and volume of sales. Examples of such problems are the study of changes in consumer demand, the introduction of new lines, the elimination or re-design of old lines, methods of displaying goods, cooperation with the advertising section in determining the desirability of local advertising, re-

search into local trade customs and buying habits, the determination of the nature and extent of competition in different territories, and similar problems. Its function is to render service to the selling organization and to the dealers in the promotion of sales. The function of the sales-planning group is to predetermine the volume of sales and to aid in the planning of sales work as far as possible. It is concerned with the analysis of territories with a view to determining their sales possibilities. In this connection it is interested, with regard to any given territory, in the character of the population, its accessibility, trade customs, the density of population, the relative extent of competition, the present and probable future state of business, and similar factors. Much of this information may be furnished by the sales-promotion group. The setting of quotas for the salesmen often is an important phase of its work. The determination of the volume of sales which should be made in each territory furnishes a definite goal toward which the salesmen can work. When coupled with some financial reward for attaining the goal, they have an incentive to make more than an ordinary effort to sell goods. The sales-analysis group is concerned with checking the results obtained by the sales force. Its work is largely that of statistical analysis. The comparison of actual sales with estimated sales, the determination of the effect of new policies and methods on the volume of sales, the study of seasonal and cyclical influences, are examples of its work. In some cases, much of it may be done by a central statistical section. In the small organization, sales promotion, sales planning, and sales analysis would be combined in one section of the sales organization.

The office organization of the sales division usually is under the supervision of an executive whose status is largely that of a chief clerk. His importance depends on the nature and size of the organization. The work of the office organization consists of the handling of sales correspondence and files, the receipt, recording, and distribution of mail within the department, the checking salesmen's routings, and similar work which is routine in its nature but essential to the smooth running of the sales organization.

The position of the credit manager in the organization is a controversial question. Some authorities prefer to combine credits and collections and place them under the financial organization. Others prefer to divorce them and place the credit work under the sales organization. Some of the recent writers on the subject [1] advocate an independent department whose head reports to some managing or higher executive in the organization. Recognition of the importance of reducing losses from bad debts to a minimum has resulted in the

[1] *Credits and Collections in Theory and Practice*, by Theodore N. Beckman.

development of extensive machinery for supplying credit information and a credit technique which requires trained ability. When credits and collections are under the sales organization they may be influenced unduly by the desire to get and hold business, resulting in too liberal extensions of credit and a weak collection policy due to a reluctance to lose customers. When credits and collections are placed in the financial organization, they may be influenced unduly by the desire to eliminate bad debts, which may result in the refusal of credit to concerns whose prospects warrant its extension, although their financial position at the moment may not. The work of collection is not undertaken until the company has fulfilled its part of the contract and the purchaser has not made payment as agreed. Often the collection department does not take over the case until all ordinary methods of obtaining payment have failed. The work requires great tact and judgment. From the nature of the problem, it seems that a credit-and-collections department is desirable which is separated from the sales and accounting organizations but which cooperates closely with them.

The advertising manager ranks usually as a major executive and reports to the vice-president in charge of sales. In addition to the usual qualities of an executive, he must have imagination, a practical knowledge of the psychology of advertising and a good technical knowledge of his profession. He is responsible for the planning of advertising campaigns, usually in cooperation with the company's advertising agency and the sales department. He assists in working out copy and checks the final copy submitted by the agency. He checks the results obtained from advertising and controls advertising expenditures under the supervision of the vice-president.

**The Financial Organization.** The financial organization is concerned with the procurement of capital for the purposes of production and distribution, the control of the use of this capital, checking the results obtained from its application, and similar functions. It is one of the three principal divisions of the industrial organization.

In the illustrative organization shown in Fig. 13, the treasurer of the company is in charge of the financial organization. He exercises general administrative control over its various departments and is directly concerned with the work of corporate financing and the control of corporate funds. In many organizations he administers only those functions which have to do with financing and the control of funds. In such cases, the other financial functions are centered in some executive who has the financial control of operations. This executive usually is called the comptroller. The requirements of the treasurer's position are such that it can be filled successfully only by a man of unusual business and financial ability, equipped with a thorough knowledge of

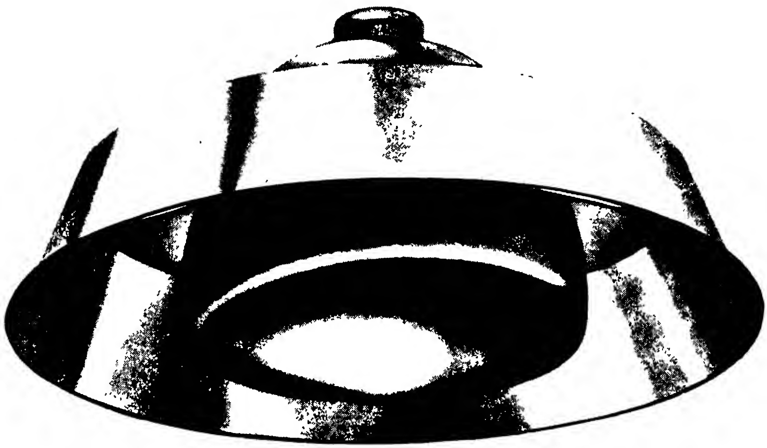
corporation finance and banking practice, good business foresight, and considerable experience in the work of financial control. His work requires a combination of abilities which cannot be found easily in one person.

The comptroller is in actual charge of the financial control of operations. In large organizations he may report directly to the president or general manager, rather than to the treasurer. Under his supervision there would probably be such departments as auditing, payroll, accounting, statistics, budgetary control, and costs. In some cases, the office manager and the manager of credits and collections might report to him.

The chief accountant maintains the records of the company's financial status and the effects of its activities on this status. He is responsible for a correct accounting of the company's assets, liabilities, incomes, and expenditures, and the origination of various financial reports necessary for the control of operations. Under him come a number of sections making up the accounting department, such as the accounts-receivable and the accounts-payable sections. In general, the various sections are specialized in the handling of certain controlling accounts. Through the operation of its books, the accounting department determines in terms of money the results obtained by the organization for a particular period. In its balance sheets and profit-and-loss statements it presents a picture of the causes and effects of these results.

The cost department records the amounts expended for labor and material in producing the various items of product and distributes the indirect expense of manufacturing over them to get the cost of each item. Usually it keeps the factory indirect expense accounts. The cost records form the work-in-process ledgers. Therefore they should be tied into the general books of the company. In some instances the cost department is placed in the production organization because much of the cost data is the by-products of production control. Time tickets, material requisitions, and expense orders are essential to the proper planning and control of production as well as cost accounting. Even so, it is essential that there be a proper linking up of the general accounts and the cost accounts. Probably the cost department can function with equal success in either organization, provided that the cost accountant realizes his obligation to furnish information which will meet the needs of both and has a sufficient background of production and accounting experience to permit him to do so.

The auditor is responsible for the determination of the correctness of the accounts. He must examine them in sufficient detail to determine the accuracy with which they have been kept. In many instances,



*Courtesy National*

PLATE 13

STANDARD REFLECTOR WITH GLASS BOWL

this means that he must go back to original sources of information and check individual entries in the books against them. The work requires not only a considerable knowledge of accounting, but patience, powers of analysis in determining the causes of discrepancies, and the ability to work accurately over a great mass of detailed data.

In those organizations which have a statistical organization the chief statistician often reports to the comptroller. He receives facts bearing on the conduct of the business from all departments. It is his function to apply statistical treatment to these facts and present them in a manner which will make their relations to management problems easily understood. The need for more refined and accurate data in connection with managerial control has resulted in considerable application of statistical methods in industry. The statistician has gained a permanent place in the industrial organization, particularly in the larger concerns.

The credits-and-collection department, in our organization, has been placed under the comptroller. As previously noted, its position in the organization is controversial.

In an increasing number of concerns an attempt is being made to predict and plan probable sales and production for a coming period, and the necessary expenditures. Budgets covering the various items of sales and manufacturing expense are set up. The expense of departments are checked currently against their budgets to determine the extent to which they are keeping within them. The work of budgetary control is under a budget director who reports to the comptroller.

**The Secretary's Organization.** The function of the secretary is to record the work of the board of directors and to transmit their policies to the organization. In this connection, he keeps the minutes of the directors' meetings, attends to the correspondence of the board, and handles the corporate books. In some instances the issue of securities and the transfer of stock are handled through his office. Because of the nature of the secretary's work, the office organization may be placed under his general supervision. The secretary should be a managing as well as a corporate executive. In many cases, however, his function is not highly developed. This is particularly true in those concerns whose management is largely a family affair. The secretary may be chosen on the basis of family connections rather than ability.

In the organization in Fig. 28, the office manager reports to the secretary. In many organizations he reports to the comptroller because the routine work of the financial organization requires a large amount of clerical service. The office manager acts as a coordinator between the various departments in so far as the performance of routine clerical work is concerned. This is particularly true in the case of the general

administrative offices. In addition, he is concerned with developing better office practice. The office manager often has direct charge of the clerical force of the general offices and of the office methods of the whole organization. Because of the nature of his work, particularly in connection with the introduction of modern office methods in departments not directly under his supervision, the office manager must possess tact and personality to a high degree, in addition to a thorough knowledge of office practice. For the same reasons, it is probable that he can work to better advantage under the secretary, provided he is competent to exercise general supervision of the office manager's work.

**The Production Organization.** The production organization is responsible for the manufacture of products having requisite quality, in quantities sufficient to meet the sales demand promptly, at a cost which will permit the company to compete profitably in so far as the factors affecting costs and profits are within its control. Usually it is the largest division of the industrial organization.

The production organization operates under the supervision of a chief production executive, who is usually called in large concerns the vice-president in charge of production. Because of the size of his organization and the varied nature of the functions which are performed by it, he must possess great organizing ability, leadership, and ability to get results. He should have a broad knowledge of technical processes. However, a detailed knowledge of the processes carried on by his organization is less essential. In many cases, a man who has succeeded in such a position with one concern also succeeds in a similar position with another. Because of the fact that he cannot be familiar with all of the operations carried on by his organization, particularly in a large plant, he must have more than ordinary quickness of perception, good powers of analysis, and good judgment. The vice-president in charge of production is a managing executive. A large number of departments, such as the production division, the personnel department, the maintenance department, the materials division, the power department, and the engineering department, report to him.

**The Production Division.** The production manager is in charge of the production division. He is directly responsible for the application of men and machines to materials in the economical production of the right quantity of goods of the right quality at the right time. In the average plant, large numbers of orders are progressing through the plant in various stages of completion. In many cases they must be completed by a given date in order that promised shipping dates may be met. In the ordinary course of manufacturing, interruptions to production, such as machine breakdowns, will occur which will tend

to prevent this. The production manager's work requires a high degree of coordinating ability, together with a thorough knowledge of production methods. The two principal phases of his work are the control and execution of production orders. Consequently, in the larger and more progressive organization the executives in charge of the planning and control of production and the operations in the directly productive shops report to the production manager. These executives may be called the planning supervisor and the general foreman or shop superintendent, respectively. Their work will be discussed in greater detail under production control.

**The Personnel Department.** The personnel department is responsible for the procurement, selection, and maintenance of the company's personnel and the proper solution of the various problems of labor relations which constantly arise in the course of manufacturing activities. The status of the executive in charge of the department varies greatly in industry, to some extent with the character of the business, but to a greater extent with the progressiveness of the concern. In this book he is called the personnel manager and is classed as a major executive, reporting to the vice-president in charge of production. The personnel manager should possess a considerable amount of social sympathy and understanding of the worker's viewpoint, inasmuch as he is dealing primarily with human rather than mechanical forces. He must have tact, personality, and the ability to win the confidence of the employees because his work is with them. In addition to the social phases of his job, there are business and managerial phases which are equally important. In connection with the manufacturing program, he should anticipate the necessity of increasing or decreasing working forces. In many instances the satisfactory solution of this problem requires some analysis of the relation of the cycles of employment and general business to the cycles of the company's business. The personnel manager should have sufficient knowledge of manufacturing methods and problems to enable him to judge the effects of proposed personnel methods on the organization. For the satisfactory solution of these as well as many other problems, the personnel manager must possess business acumen in addition to his other abilities. The work of the personnel manager has passed beyond the stage where it can be placed in the hands of an intelligent clerk and forgotten. Its technique has been developed and improved to the point where specialized training is required for its successful supervision. The principal functions of personnel work are employment, medical supervision, employee service work, education and training, and the development of personnel standards. While the personnel organization will vary somewhat with each concern, the

larger organizations often have a specialized executive in charge of each function.

The employment section, under the supervision of an employment supervisor, who reports to the personnel manager, has the function of labor procurement and to some extent maintenance. It performs such work as selection of employees, hiring, placement, transfer, promotion, wage control, and separation. In addition it keeps employee and other personnel records. It replaces the old haphazard, cut-and-try method of hiring and firing until the right man for a given job is secured, with more scientific employment methods. It can do much to reduce labor turnover, one of the great causes of indirect expense and loss in many concerns.

The service section endeavors to develop and maintain the morale of the working force and an *esprit de corps* based on sound labor relations. It approximates as far as possible the human relationships which existed prior to the great aggregation of capital and integration of industry which characterize our modern industrial economy. It administers or assists such employee services as shop papers, employees' councils, suggestion systems, social or athletic activities, the plant restaurant, employee housing, pension systems, group insurance, workmen's compensation, length of service bonuses, safety work, and many others. A service supervisor who reports to the personnel manager is in charge of the department.

The medical section is concerned with the development and maintenance of the physical efficiency of the company's human assets. In industry, it has developed as a result of a growing realization of the relation between the employees' health, fatigue, and production, stimulated in part by labor legislation for the control of accidents, occupational diseases, and other industrial problems. Some examples of the work of the medical department are the physical examination of applicants for jobs, periodic health surveys of the personnel, plant sanitation, the operation of industrial hospitals, and the study of fatigue and occupational diseases. The section is under the supervision of the plant physician or medical supervisor.

The education and training section has the problem of increasing the average knowledge and skill content of the personnel with particular regard for the needs of the organization. It provides an opportunity for self-development, a requisite for real interest in one's job and maximum production. It reduces the time and expense of training new employees. It does much to develop and maintain the morale of the organization. As its name suggests, the principal phases of its work are training and education. Training involves training for a craft and training for a specific job. It includes the supervision of

whatever training methods may be used, such as the apprentice system. Plant education is concerned with such problems as the continuation of the education of young employees, the development of plant schools for giving general instruction to employees in subjects which will benefit them in their work with the company, the use of plant libraries, the publication of the plant paper, and many others. The section is under the direction of a supervisor of education and training.

In some plants, there may be a standards division, engaged in the development of better personnel methods. The work consists of the making of job analyses for the determination of the personnel characteristics of the various jobs, the development of rating scales for determining the relative values of employees, the development of analytical records of labor turnover, and similar problems.

**The Materials Division.** The materials manager has charge of the materials division of the production organization. He is a major executive, reporting to the vice-president in charge of production. His division is responsible for the procurement of materials, their proper receiving, stowing, and ultimate delivery to the job, the economical control of inventories, and the salvaging of waste and scrap materials. He should be a high-grade executive with a good knowledge of markets, materials, and the work of purchasing. In many cases, whether or not the company makes a profit depends to a large extent on his ability to analyze the business outlook correctly, with regard to its probable effect on the markets for the materials that he must purchase. He should have a good practical knowledge of accounting and finance as much of the work of his organization must tie in with the work of the accounting and financial organizations. He must be reasonably familiar with the rapid developments which have taken place in connection with methods of storing, handling, and salvaging materials. He should be sufficiently familiar with production-control methods to permit him to cooperate intelligently with the production division. In a large organization, developed with regard to the major material-control functions, the purchasing department, the balance-of-stores department, the stores department, and the salvage department may be under the general supervision of the materials manager. In small concerns it is necessary to combine functions and departments in the interests of economy. However, in any such combination, the functions should be clearly recognized and provision made for their proper administration.

The purchasing department is usually under the supervision of a purchasing agent. Its chief function is the procurement of materials by purchase. It must obtain what is wanted, when it is wanted, at the most advantageous price consistent with quality, delivery, and the

quantity required. The purchasing agent is a specialist in materials, markets, prices, and the technique of purchasing. In many concerns, his function is highly important. Unwise purchases may result in serious losses due to subsequent price declines or excessive inventory charges. Failure to deliver materials when wanted may interfere with production. In many ways his work affects the profitable operation of the company. Under him, there is an organization of buyers, follow-up clerks, invoice clerks, and record clerks. In some instances the traffic manager may report to the purchasing agent.

The balance-of-stores department, or stores-record section, as it is sometimes called, has the function of controlling and accounting for the materials inventories. It is under the direction of a balance-of-stores clerk, who reports to the materials manager. Its work is largely clerical and includes the checking of inventories, receipts of material, purchases of materials against requirements, protection of stock against depletion, furnishing the planning department with information necessary to its work, and similar duties. The principal instrument for performing these duties is the stores ledger, in which are recorded all requirements, orders, receipts, withdrawals, and other pertinent information for each item of materials in stores. The balance-of-stores clerk should be a good detail man with some knowledge of industrial accounting and ability to handle a considerable amount of routine clerical work. In addition to the ledger section, there may be an order section in his organization which originates purchase requisitions for supplies and many materials of a nonspeculative nature, and manufacturing requisitions for those materials and supplies manufactured in the plant.

The stores department is the physical custodian of the material inventories. It differs fundamentally from the purchasing and balance-of-stores departments in the respect that they are concerned with the clerical handling and control of inventories. The stores department is concerned with their physical handling and control. It may perform such functions as receiving material into the plant, storing it pending its withdrawal for production or other purposes, the delivery of materials to the job, and the shipping of the finished product. A stores superintendent who reports to the materials manager is in charge of the department. His organization may include some or all of the following units—the receiving department, the storerooms, the shipping department, and the internal transportation department.

The last of the major departments of the materials division is the salvage department. It is under the supervision of the salvage foreman, who reports to the materials manager. Like the stores department, it is concerned with the physical handling of materials. Its

functions are to process or dispose of waste and scrap materials to the best advantage, to develop salvage processes, to reduce the volume of scrap by educating the organization in the matter of scrap reduction. In recent years, the problem of industrial salvage has received considerable attention, with the result that there has been developed much specialized equipment for the reclamation of materials. The modern salvage department is largely a manufacturing department. Quite often its operations result in considerable savings. Where the salvage function is well developed, the salvage foreman usually has charge of three sub-departments—the sorting department, the salvage shop, and the salvage yard. The sorting department sorts the scrap into classes, kinds, and grades. The salvage shop works the scrap into that form in which it can be disposed to the best advantage. The salvage yard stores and ships salvaged materials to such purchasers as can be found.

**The Engineering Department.** The engineering organization is concerned primarily with the application of the physical and chemical forces of nature in connection with the design of the company's product and the tools and processes with which it is produced. It considers such problems as improvements in the design of the product, the design of new products, the design of tools and special equipment for the processing of the product, research work in connection with the development of the product and production processes, and similar problems. The department is under the supervision of a chief engineer, who reports to the vice-president in charge of production.

The chief engineer must have a thorough knowledge of engineering practice and its applications to the design of the product. His work requires a highly analytical mind of the mathematical and research type. He must have imagination and vision. Good executive ability is equally as important as good technical ability. It is exceedingly difficult to schedule the work of the engineering department. Yet it must be controlled as far as possible because its performance affects the other work of manufacturing which follows. A well-made production schedule may be disrupted by the failure of the engineering department to deliver blue prints and bills of material as promised. The various engineering sections which report to the chief engineer differ with each organization, depending largely on the character of the product, the manufacturing problems, and the extent to which the engineering function has been developed. The more common engineering executives who report to the chief engineer are the product engineer, who is responsible for the design of the product; the production engineer, who is responsible for the design of the tools and other production equipment; the chief draftsman, who is responsible for the detail work of placing the engineer's plans in permanent and usable form for

the shop; the experimental engineer or research director, who is in charge of the laboratories and the research work; and the chief clerk, who has charge of the engineering office organization.

**The Methods Department.** The methods manager or industrial engineer is concerned primarily with the efficient application of the human forces of the organization. He is responsible for the proper development of organization and system. In general, his problems are those of applied economics, while the chief engineer deals, for the most part, with problems of the applied chemical and physical sciences. The scope of his activities usually includes such work as the development of production-control methods, material standards in cooperation with the engineering department, and other work leading to the development of better operating methods. The time-study department may be under his supervision. Although the function of developing better management methods may vitally affect the success of the concern, the methods manager is the least common of the major industrial executives.

**The Power Department.** The function of the power department is the generation and transmission of power to the plant. It is administered by a power superintendent who reports to the vice-president in charge of production. In a large organization he should be a competent heat-power engineer with the rank of a major operating executive. In many industries the cost of power is one of the important items in the cost of production. In such cases the proper handling of his function is important. There has been some tendency in recent years, particularly where water power is available, for industrial plants to purchase power from central power stations. Whether the purchase of power from a central power station is economical depends to a large degree on the extent to which steam is used in heating the plant and in the various processes. Where the company purchases its power, of course the power superintendent does not appear in the organization.

**The Maintenance Department.** The function of the maintenance department is to maintain the physical efficiency of the plant, machinery, and equipment and to anticipate and prevent interruptions to production due to their failure to give proper service. The proper handling of this function is necessary to the satisfactory control of production. Maintenance work is difficult to control and supervise, inasmuch as it is impossible to tell when emergency breakdowns will occur. In addition, maintenance work is scattered throughout the entire shop. The three principal phases of maintenance work are (1) the anticipation and prevention of emergency breakdowns by regularly inspecting the plant, machinery, and equipment, (2) the making of such emergency and other repairs as may be necessary, and (3) plant

service such as elevator service, window-washing, and similar work. For the performance of such varied work, a large maintenance organization may include such units as the carpenter shop, pipe shop, janitor service, maintenance inspection service, millwrights, and similar groups. The department is under the supervision of an executive, called variously the maintenance superintendent, master mechanic, or works engineer, who reports to the head of the production organization.

In the preceding discussion, an organization has been developed which would be economical only in a large plant. As was stated at the beginning of the discussion, management functions in the large plant are greatly magnified and can be studied in detail. An executive may be in charge of a department which performs a single function. The same functions are present in the small plant, but in the interests of economy, an executive and his department may perform a number of functions. As a result, it may be difficult to distinguish the different management functions clearly. Yet the same fundamental laws of management govern them and it is equally important that adequate provision for their proper performance be made. It is not particularly important that the management mechanisms are simpler and somewhat different, because in any case it is desirable that the system be developed to meet manufacturing conditions in the particular plant.

## CHAPTER VII

## SYSTEM

**The Importance of System.** System has been defined as the normal routine by which the operations of the business are carried on and controlled. The organization is the machine of management. The system is the tool with which it continuously achieves results. The orders secured by the sales force are the energy that keeps the machine operating. Just as a well-designed machine may fail to produce satisfactory work because the tools are poorly designed, so a good organization may fail to produce results because the system is crudely or inadequately developed. In a great many concerns the system is built as the need arises. An emergency occurs; a meeting of the executives concerned is called; a method of meeting the situation is devised; little thought is given to the system until another emergency arises. Under such conditions, the system is largely the result of expediency. Usually, much of the knowledge of the various routines and the manner in which they operate is carried in the heads of executives and clerks. When one of them leaves the organization and must be replaced by an inexperienced employee, the effectiveness of the system may be reduced materially. Obviously, the organization cannot accomplish the same results that it could if the system were developed as the result of a careful analysis of the problems of management as a whole as well as of the particular problem under consideration.

**Fundamental Considerations in the Development of System.** As far as possible, the system should be the result of a steady, homogeneous growth of routine, developed through the consistent application of methods of scientific analysis. Inasmuch as it is an important tool of management, it merits careful, constant study. In addition to this consideration, which is equally true of many of the problems of management, there are the following considerations which apply more particularly to the development of system: (1) control through sound policies, (2) regard for the proper performance and control of functions, (3) the development of standards, (4) the use of definite written instructions, (5) the training of the organization, (6) the development of an adequate system of reports, (7) the development of records, (8) the provision for proper administrative and executive control and supervision, and (9) the provision of adequate incentives.

**Policy.** A policy is a definite, settled body of principle and procedure governing a given course of action. It may or may not be stated in written form. A sound policy has three important characteristics, (1) it is based on a careful analysis of the aims and characteristics of the business, (2) it is definite, and (3) it has stability. A policy should be a fundamental directive, guiding the organization along the path of consistent progress. Its formulation is affected by such factors as custom, public opinion, factory legislation, the character of competition, the nature of the management problems, and the aims of the business. It can hardly accomplish its purpose unless it is made as a result of a careful study of these factors. Sound policy determines the objective toward which the organization is working. It prevents deviations from the course of action selected as best for the attainment of these objectives. It furnishes a solid foundation on which the activities of the organization can be based. The various policies of the organization should be complementary to one another, in order that they may promote harmony and cooperation. Therefore an analysis of the fundamental functions involved, and the requisites for their successful performance, is a necessary prerequisite for the formulation of successful policies. In many organizations there is a tendency for the various units to function independently. The success of a given unit becomes its primary objective rather than the success of the organization as a whole. When policies are the result of a thorough analysis of the business and its needs, they tend to coordinate the organization units and to relieve such a situation. A careful study is of little value unless the organization understands the policies and their application. For this reason they must be definite. Otherwise there is danger that the organization will work at cross purposes, causing confusion and lack of effectiveness. To avoid it, policies should be stated clearly and concisely, in written or printed form. This is particularly desirable in the case of those policies which affect the public and which are intended to secure its good will. Indefiniteness tends to provoke suspicion. In many concerns the policies are changed frequently. This may be due to the fact that they are not well thought out, the company has never definitely determined its objective or is prone to take advantage of passing situations which seem to offer an opportunity for profit. Under such conditions the organization never becomes thoroughly familiar with the policies or experienced in their application. As a result they fail to produce the benefits that were expected of them. The company may often secure additional profits by the sacrifice of stability of policy but in the long run, the losses from such sacrifice may offset the gains. Obviously, a lack of policy stability tends to prevent the building of a widespread, lasting reputation in any

particular field. Furthermore, it reacts negatively on the morale of the organization. The frequent changes in system resulting from shifting policy keep the whole organization in a state of turmoil. The situation suggests lack of force of character, experience, or ability. It may cause a loss of respect for the organization's managing executives. Stability of policy should not result in the freezing of organization and system in their present state of development. It merely requires that suggested changes in policy be subjected to rigid examination to determine their future as well as their present value.

Policies may be classified according to their scope as, (1) general, (2) major, and (3) minor policies. The general policies are those that govern the general conduct of the business. They lay down the basic principles upon which its operations are conducted. They state its objectives. They form the basis of future plans. To some extent they may affect the public. On the basis of their effects, they may be classified as internal and external general policies. In accordance with this classification, the general policies governing the distribution of the company's product for the most part are external. Those governing the production of the company's product for the most part are internal. The general financial policies may be equally internal or external. The major policies govern the administration, performance, and control of the major functions of the business. In order that there may be unity in the policy structure, it is necessary that they conform to the general policies. The minor policies govern the conduct of the various organization units.

The mere statement of definite, stable, well-conceived policies is not sufficient to insure that these policies will actually operate as fundamental directives. Many concerns are able to show beautifully printed statements of excellent policies. Investigation often shows that these policies are only partially applied or are entirely disregarded by many executives. To insure their successful application they must be constantly checked as to their effectiveness and the manner of their application. The more common means of insuring the proper application and administration of policies are the committee system, which often gives a consensus of executive opinion regarding the operation of various policies, a good system of executive reports, the use of standard practice instructions and various educational instruments such as the plant paper and the shop bulletin boards.

The importance of policy in the development of system should be obvious. It is the foundation upon which the system rests. If the policy structure is poorly conceived, it is probable that the system will be ineffective.

**The Proper Performance and Control of Functions.** The various functions of manufacturing should be analyzed and studied to insure that the structure of the organization will facilitate their proper performance and control. Similarly, they should be analyzed and studied to insure that the system provides an adequate normal routine for the performance and control of each function. In the ideal system, it should be possible, as the conditions of the business change, to extend or curtail the operation of the various routines, to increase or decrease the amount of information in executive reports, to alter the character of this information without affecting the efficiency with which the various functions are performed. While this ideal cannot be attained in practice, the system should have the maximum flexibility. Such flexibility can hardly be obtained except as the result of a careful analysis of functions and their relations to the system. Furthermore, the system should promote specialization. Mr. L. P. Alford states the laws of specialization as follows: [1]

(*1*) *Law of Division of Work.* Subdividing the work so that one or a very few manual or mental operations can be assigned to a worker tends greatly to improve the quality and increase the quantity of output.

(*2*) *Law of Division of Effort.* Assigning to each worker one or a very few manual or mental operations which he is particularly adapted to perform greatly improves the quality and increases the quantity of output.

As a corollary, Mr. Alford states,

(*1*) *The Law of Functional Management.* The highest managerial efficiency is obtained by functionalizing the duties of the executives.

It is evident that these laws must be considered in the development of both organization and system. In connection with such consideration, a careful analysis of functions and their relations to the system again is important.

Functions may be classified according to (1) general classes of managerial endeavor and (2) phases of manufacturing activity. Under the first classification, three classes of functions usually are recognized, (1) administrative, (2) staff, and (3) executive. The administrative functions have to do with the making of policies, the general guidance of the organization, the determination of its results as a whole rather than for each organization unit, the placing of responsibility for results on the executives in charge of the various major divisions of the organization, and the granting of proper rewards for accomplishment to these executives. Of course, such rewards may not be monetary, but may be merely recognition and commendation. For the most part, the administrative functions have a legislative and

[1] *The Laws of Manufacturing Management*, by L. P. Alford. Presented at annual meeting, A. S. M. E., December, 1926.

judicial character. In general, the staff functions are service functions for the administrative and executive functions. As such they are essentially advisory. In most cases they are specialized functions which have been split off from general functions of manufacturing activity. The cause of their development is the increasing need for expert advice in the various phases of manufacturing activity as the magnitude of operations increases. The engineering function is an example. The executive functions are concerned primarily with the control and supervision of actual performance. The classification of functions on the above basis depends somewhat on the point of view. In so far as the shop organization is concerned, the planning department usually can be classed as a staff function. From the standpoint of the company organization as a whole, it is an executive function.

Functions may also be classified according to phases of manufacturing activity. The three great functions of manufacturing are (1) sales, (2) finance, and (3) production. These in turn may be divided into various sub-functions. For instance, the general function of production can be broken down into a number of sub-functions, such as material control, maintenance control, production control, personnel control, and others. Each sub-function can be broken down into numerous minor functions. Such a classification is useful in studying system.

**The Development of Standards.** A standard is that which is established by authority, custom, or general consent as a model, criterion, or rule for measuring. The law of standardization in manufacturing may be stated as follows: *the determination and use of the best criteria for the conduct of operations reduces the cost of manufacturing.* Usually standardization in industry is thought of as having to do with the fixing of types, sizes, and characteristics of product. However, the term has a much broader significance. We may have temporary standards of performance such as are set up by manufacturing budgets. We may have permanent standards of method and performance such as are determined by time and motion studies for operations in the manufacture of the product. We may have standard routines. Many other examples of standardization are found in industry, which are only indirectly related to the fixing of types, sizes, and characteristics of the product.

Routines cannot operate with maximum effectiveness unless they are reasonably stable. In some concerns the same problems are rarely handled in the same way twice in succession. Under such conditions, the organization is never sure as to what is the best way of handling a given problem. The selection of a method depends largely on the judgment and experience of those executives and employees immedi-

ately concerned. It is inevitable that costly mistakes and inefficiencies will result. Before the system can be stabilized sufficiently to enable the organization to become thoroughly familiar with it and skilled in its use, the basic factors in manufacturing which affect the system must be standardized. If the character and value of these factors are constantly shifting, then the system must constantly shift also. Therefore the effectiveness of system depends to a large extent on standardization. For example, it does little good to set up a routine for scheduling unless some standards of performance have been worked out and manufacturing conditions have been standardized. The routine itself will be of little value unless it can be standardized to a considerable degree and the standard method enforced. The matter of standardizing routines will be considered in more detail later.

**Definite Written Instructions.** Despite all that has been said regarding the value of written instruction, they are not used to a sufficient extent in many concerns. When instructions are given verbally, it is difficult to attain reasonable stability of system. What might be called an evaporation of system is likely to occur. As time passes, the memory of the exact nature and meaning of particular instruction grows dim. It is difficult to break old habits and to form new ones. As a result, there is a tendency of executives and operatives to slip back into former methods. The best routine for handling a given problem is forgotten, disregarded, or distorted. Furthermore, verbal instruction must be handed down to succeeding generations of executives and operatives by word of mouth.[1] It is not probable that in each instance the instructions will be transmitted with exactly the same words that were used by the executive who originated them. There is the danger that with each transmission there may be some unintentional perversion of the original intent. It is also probable that each generation of executives and employees will place its own interpretations on the instructions because in most instances verbal instructions to some extent lack definiteness and completeness of detail. While the perversion of instructions may be slight at each transmission, the cumulative effect may be such that in the course of a few years they may have been distorted almost beyond recognition. Even in the case of instructions which relate to current operations rather than to the establishing of permanent routines, written instructions have the advantage that they insure that such operations will be carried on exactly as directed. Again, verbal instructions are subject to interpretations and error in transmission. In fact, it is likely that if an executive must give verbally the same original instructions to a number of executives he

[1] The average life of a generation of employees may vary from a few months to a few years, depending on the rate of labor turnover.

will not give them to each one in exactly the same form. Therefore verbal instructions will not facilitate the coordination of effort to the same extent that written instructions will.

Written instructions have the advantage that they are a deterrent to hasty action. It is not uncommon to have orders which have been issued over the telephone by a busy executive rescinded within a relatively short time because certain factors in the situation have been overlooked. In the meantime considerable time and effort may have been wasted. The system may be thrown into confusion temporarily. When an executive must sign his name to written instructions, he will usually give them more careful consideration than when he issues them verbally. He is placing himself on record. As a result, the organization will receive better and more detailed instructions, and probably fewer of them. Obviously this is desirable because a clear, thorough understanding is necessary for the intelligent execution of orders and the satisfactory operation of system.

**The Training of the Organization.** The effectiveness with which the system is operated, as well as the productiveness of the personnel working under it, depends, to a considerable degree, on the organization's understanding of the system and skill in operating it. Therefore, the effective development of system implies a continuous increase in the skill content of the organization, individually and as a whole, through proper training in the performance of the various procedures. The training of the organization depends, to a large extent, on stable policies and definite, written instructions, properly conceived.

**An Adequate System of Reports.** The purpose of executive reports is to indicate the degree of success of policies, methods, and operations, to aid the direction and supervision of the organization by showing where and why it is failing to obtain anticipated results, to show where censure, praise, and reward should be placed and to what extent. As in the case of instructions, reports may be written or verbal. In relation to time, they may be periodic or special. Most of the objections to verbal instructions hold for verbal reports. There are so many kinds of reports that it is inadvisable to discuss their respective characteristics except as such discussion may be necessary in connection with discussions of various phases of management in subsequent chapters. However, there are certain common characteristics of good reports which should be noted.

As far as possible, reports should be brief and concise in order to conserve the time of the executive who must examine them. Only such detail should be included as is necessary to give them clarity. Where possible it should be presented by means of graphic representation to facilitate the executive's analysis of the situation. In the case

of operating reports, the exception principle should be applied.[1] By this is meant that only the exceptions to the established practice should be called to the executive's attention. Usually such reports are received at regular periods. As long as his department operates normally, the executive is not interested in the details. His time should not be wasted in examining information on which he has no occasion to act. Accordingly, reports for responsible executives should be gone over carefully by assistants and the exceptions to established practice indicated by underscoring or other means. Furthermore, reports should be comparative in order that the nature of the exceptions may be indicated. To illustrate, in parallel columns monthly department expense accounts may be compared with the budgeted expense for these departments. In some concerns, operating statistics are compared with corresponding figures for the previous month and the same month in the previous year. Special reports of investigations involving considerable data should be constructed on the same principles. The first part of the report should be a brief, concise summary of it. The summary should state the nature of the problem, the method employed in the investigation, the results and conclusions, and any recommendations. Throughout the statement of results, conclusions, and recommendations, reference should be made by page number to supporting data in the body of the report. If any question is raised in the mind of the executive regarding a particular point, he can satisfy himself by turning to that part of the report which deals with it. If no question is raised, he can approve the report without first wading through a mass of detail data, much of which he may not be qualified to judge.

An essential attribute of a good system of reports is promptness. In most instances, when a situation arises which interferes with the operations of the plan, it must be dealt with promptly if loss is to be avoided. Unless reports bring such existing or impending situations promptly to the attention of the responsible executives, they lose much of their practical value. To illustrate, if production is held up by the failure of material to arrive as scheduled and the interference is not called to the attention of the responsible production and purchase executives until it occurs, it is too late to avoid considerable loss to the company. A good system of follow-up for purchase orders, which would insure prompt reports on those orders which are in danger of falling behind schedule, might have permitted these executives to take the proper measures to avoid the loss.

**The Development of Records.** The development of operating records is necessary to the successful operation of the system. The records may be the history of previous operations or they may be

[1] *Shop Management*, by F. W. Taylor, p. 126. 1919 Edition, Harper and Brothers.

compilations of data secured by research, as in the case of most time-study records. Records are used to determine by comparison the worth of present accomplishments and to predetermine, plan, and prepare for future accomplishments. It is of little value to work out a method of production control unless we also develop records which will tell us the list of operations through which the product normally passes, the work center where each operation is performed, the type of machine which should be used, the approximate time required to process each operation, the kind of material used in the product, the amount required for each unit of product, and similar information. It is possible, of course, to overdevelop records and to record the activities of the organization in too great detail. Information may be recorded which is interesting but not essential to the work of the organization. As a result money is spent for clerical work for which no adequate return is received. Any records which are little used are open to suspicion. To be of greatest value, the information contained in the records must be reliable and in such form that it is readily available.

**Proper Administrative and Executive Control and Supervision.** The field of administration includes the making of policies, the general guidance of the organization, the determination of its results as a whole, the placing of responsibility for such results, and the granting of proper rewards for accomplishment. The field of management has to do with the guidance and control of the organization in the performance of its various functions. The relation between the fields of administration and management is diagrammed below.[1]

| | |
|---|---|
| Administration............................ | Purpose<br>Policy<br>Plan (general) |
| Management............................ | Program<br>Project<br>Plan (detail)<br>Procedure<br>Preparation<br>Performance |

The administrative executive is concerned with purposes because he must determine definitely the ideals and objectives of the organization; policies because they are the definite principles of procedure on which any consistent effort to attain these ideals and objectives must rest; general plans because they give to the organization general methods

[1] Developed from a similar statement by Dr. Harlow S. Person, Managing Director, The Taylor Society.

of action, which must not conflict with the company's ideals and policies; programs because they determine the order of future activities. By their very nature, programs are the connecting links between the fields of administration and management. The managing executive is concerned with projects because they are the specific undertakings; detail plans because they are the specific methods of action employed in accomplishing a given undertaking; procedures because they constitute the manner of conduct of the undertaking; preparations because the extent to which the undertaking can be successfully conducted and executed is affected greatly by the extent to which the various conditions necessary for successful accomplishment are present before operations are begun; performances because they are the acts of execution which should result in the successful accomplishment of the undertaking. Obviously, detail plans and procedures should not conflict with purposes, policies, general plans, and programs. Evidently, there is no sharp dividing line between the two fields. The work of administration and management, then, consists largely of the determination and accomplishment of purposes, policies, plans (general), programs, projects, plans (detail), procedures, preparations, and performances.

The quality of the work of management, using the term in a broad sense to include administration, varies with the type of management. Three types usually are recognized—(1) conventional, (2) systematic, and (3) scientific management.[1] Conventional management is characterized by expediency. As various problems arise, policies and methods are devised to cope with them. Usually the need for a solution is such that it is not possible to give the problem adequate study. It is unlikely, therefore, that routines will be developed as the result of a thorough analysis of management problems in accordance with fundamental, rational development policies. They are, for the most part, rule-of-thumb methods based on the experience of the organization. While it may produce results, usually it is in spite of the system rather than because of it, and the results are far from the possible maximum. Systematic management is characterized by a desire for better management methods, but not by the use of methods of scientific analysis in their development. Methods which have been used successfully in other plants are adapted to the needs of the organization as far as possible. The development of system becomes a cut-and-try process. If system is to operate with maximum effectiveness, it must be based on a thorough analysis of the management problems of the plant. It must be developed through the application of sound principles of management to meet its particular needs. Therefore it is unlikely that

[1] "Industrial Administration and Scientific Management," by Forrest E. Cardullo in Thompson's *Scientific Management.* See also "Unsystematized, Systematized and Scientific Management," by Henry P. Kendall, *ibid.*

routines used in one plant can be adapted to the needs of another and operate with maximum effectiveness. Two concerns manufacturing identical products will differ in personnel, in physical equipment, and in many other ways. This does not mean that the methods of other plants cannot be studied profitably. On the contrary, they may represent interesting applications of fundamental principles of management. Systematic management will produce much better results than conventional management, but for the above reasons it will not produce maximum results. Scientific management is characterized by the application of methods of scientific analysis to the solution of management problems. The problem is analyzed into its elements. Data relating to these elements are collected and studied to determine their characteristics and their relations to one another. The best series of elements is determined and synthesized into the one best solution for the problem. Under scientific management, system is developed as the result of the application of sound principles of management after such an analysis has been made. Only in such a manner can a system be developed which will produce maximum results.

Administrative and executive control and supervision involve the use of the various tools of management, such as policies, routines, standards, definite and complete instructions, reports, and others, in the coordination of the organization's activities. It is concerned with the development of system along the lines indicated above and is an essential part of it. By control is meant the instruction and guidance of the organization and the direction and regulation of its activities. It involves four fundamental steps—(1) the predetermination of reasonable accomplishment, (2) the issuance of definite and complete written instructions, (3) the analysis of reports and the comparison of actual and predetermined accomplishments to determine the causes of variations, and (4) the recognition of responsibility for final results. By supervision is meant the superintendence or overseeing of performance. As Robinson points out,[1] supervision analyzes and interprets policies and instructions and sees that they are actually followed in operation. It discriminates between changes of method that are voluntary and desirable and those which are involuntary and undesirable. As previously pointed out, there is the constant tendency for system to shift to some former basis or to one dictated by expediency. Proper supervision should stimulate the employee to give maximum production willingly rather than provoke a sullen desire to soldier at his work. Such cooperation can be had only when the executives lead rather than drive their subordinates; when their supervision is based on frankness, honesty, and fair dealing and is tempered by a considerable regard

[1] *Fundamentals of Business Organization*, by Webster Robinson, p. 137.

for the individuality of the employee. To get the best supervision, planning and supervising actual performance should be separated. Such a division of effort conforms to the laws of specialization. Very often the man who has considerable capacity for analyzing and planning may have little capacity for supervising performance. Similarly, an executive who can get maximum production from his employees may have mediocre analytical abilities. Furthermore, the work of supervising actual performance is usually so complex that proper planning of work is likely to suffer by neglect if the two are combined.

**The Provision of Adequate Incentives.** An incentive is any stimulus which tends to incite to action. In industry, those stimuli which tend to incite the employee willingly to give greater cooperation and production, play an important part in the development of system and the work of management. Such incentives tend to increase production and to decrease labor turnover. They tend to stimulate the interest of the worker in his job, improve the morale of the organization, and develop that cooperation which is essential to the successful operation of system.

Self-interest is one of the most powerful motives. Consequently, most incentives are designed to make use of it. They can be grouped into two general classes, (1) nonfinancial and (2) financial.

Nonfinancial incentives are those which do not directly depend on monetary rewards for the employee. The distinctive badge worn by those who have completed twenty years or more of service with the company; the posting in each shop of names of the employees in the order of their productive efficiency; the recording on his personnel record of the employee's production, scrap, attendance records, and other information to be used in determining his suitability for promotion; the improvement of lighting, ventilation, and other conditions of work; the granting of special privileges to those who have been with the company a stated length of time—these are examples of nonfinancial incentives. If properly tied in to the system, they promote its effective operation.

Financial incentives are those which depend directly on monetary rewards for the employee. Examples of financial incentives are bonuses for attaining or exceeding the standard rate of production, bonuses for maintaining the standards of quality, and bonuses for perfect attendance. Group insurance, length-of-service bonuses, profit sharing, stock-sales plans, and many others are in the borderland between financial and nonfinancial incentives. They provide financial rewards, but the rewards usually are long deferred. In general, the financial incentives are more powerful than the nonfinancial. They play directly on the motive of self-interest.

**The Interdependency of Routines.** System is composed of interdependent routines. The various steps in a routine may lead through a number of departments. At certain steps, the machinery for the performance of different functions may be set in motion. In the development of system, the functions of the organization must be studied, as previously pointed out, and the relations of the various routines to one another.

**Standard Practice Instructions.** Standard practice instructions are intended to insure the continuous, orderly advance of operating methods. When properly developed, they form a written code of practice for the management of the business. After the best method for performing and controlling a given function has been determined, the standard practice makes a permanent record of it and aids in its uniform application throughout the plant. It reduces the probability of a gradual deviation from the one best method.

The standard practice may be divided into three parts—the mechanical data, the summary, and the detailed procedure. Heading the standard practice is its title and the purpose of the routine, the date when the standard practice becomes effective and the serial number of the practice. The section dealing with mechanical data contains such information as the executives or departments affected by the change in practice, the forms used in connection with the method, necessary equipment, and similar data. The summary contains a general description of the old procedure, followed by a summary of the new method. This arrangement affords a quick general comparison of them. Under detailed procedure comes the detailed description of the new method. Subheadings are used to indicate the operations performed by each executive or department affected by the standard practice. The manner in which these subheadings are used is shown in Fig. 14. This arrangement conserves time. The summary gives the general background of the practice. It is only necessary for the employee or executive to read those portions whose headings indicate information of particular interest to him. In writing up the detailed description, the forms used should be referred to by their serial numbers as well as their names. A copy of each form is mounted in the back of the standard practice.

There may be considerable opposition to the development of standard practices. The more common causes of opposition are the executive's fear that he is giving away his job and the fear that the standard practice will reduce the importance of his job, making him more or less of an automaton. Neither of them has any great foundation in fact. Usually, there is nothing unique in the methods which the executive has developed. In most cases they are merely variants of practices

Reference: Cartridge Department  Standard Procedure No. K148

Subject: Control And Closing Of Production Orders.

Forms Used: Production Report 1830  Production & Scrap Lot
Scrap Report 1831  Record 1932
Sub Order 1887  Comparative Cost Card 2148

Functions Affected:
Depts: Cartridge
Sections Scheduling, Planning, Central Files, Industrial Engineer's Office.

**This Procedure Is To Be Followed And No Change**
**Is To Be Made Unless Authorized On This Form**

1. Shops

a. From the Tally Sheet form #1836, the Time Keeper will prepare daily a Production Report 1830 and Scrap Report 1831 in triplicate.

b. Copies of the Production & Scrap Report will be sent to:
Original - Departmental Scheduling Section.
Duplicate - Group Office.
Triplicate - Retained in shop for use of Assistant Production Overseer.

7. Production Superintendent's Office

a. On receipt of Production Order and after comparison with office statistics, the copy of the Production Order will be delivered to the Planning Section which will enter on balance sheets the unit price of the product as given on the Production Order, afterwards forwarding the Production Order to the Central Files for permanent filing.

Industrial Engineer.

Approved

Date Effective ________  Sheets 3  Sheet No. 3

FIG. 14
STANDARD PRACTICE INSTRUCTIONS

which have been used in other establishments and which are known to students of management. The sudden loss of an important executive usually causes considerable inconvenience and loss, regardless of how good an understudy may have been developed for the job. The value of experience should not be underestimated. Almost never does the loss of an executive permanently cripple the organization for the reasons given above. The determination of the best methods of performing and controlling the functions of the organization enables the executive to perform his duties more efficiently. High operating efficiency is a sounder basis for preferment in the organization than the hoarding of some specialized knowledge for use as a club over the management. Furthermore, by putting the routine work of management in standard form which is readily understood and easily learned by the employees, the standard practice relieves the executive of much unnecessary work of supervision. His mind is free to deal with the major problems involved in the administration of his functions. In this respect, the standard practice may foster rather than kill initiative.

**The Steps in the Making of a Standard Practice.** For the reasons indicated above, the development of the standard practice requires considerable tact and diplomacy. If the antagonism of the organization is aroused, the work will be seriously hampered if not made impossible. The first step, therefore, is to sell the executives on the advantages to them of standard practices. After reasonable cooperation has been assured, the next step obviously is to determine the present practice. In some instances this has been done by requesting each person who has anything to do with the routine under consideration to submit a statement of the duties which he performs in connection with it. Because of the press of work or lack of training, most clerks and executives will not do this accurately or completely. It is more satisfactory to interview on the job the executives in charge of each phase of the routine and the clerks who perform each step. Often a considerable mass of data may be collected which may be difficult to analyze in its crude state. Therefore the third step may be to work up the data into some semigraphical form. This form is usually called a routine chart and will be discussed later. The routine chart furnishes a complete picture of the routine as a whole and the relation of the different steps to one another. The fourth step is the analysis of the chart and the supporting data to determine what steps in the present routine are fundamental to the successful performance and control of functions and what are not, aided by any suggestions for the improvement of the present routine which have been made by the employees interviewed. Steps in the routine may be cut out, altered, their sequence changed, forms redesigned, and other changes made with a view to

developing the best routine for handling the particular problem. When it has been determined, the fifth step is to work up the new routine into a routine chart for final analysis. It is then written up in the standard-practice form. Before it is finally approved and issued, it should be submitted to those executives who are affected by it, for their approval. Two things may be accomplished by doing this. In the first place, each executive is more familiar with the requirements of his work than any analyst can be after a necessarily limited study of it, unless he is fortunate in having considerable experience with the particular type of work. Often an executive is able to point out opportunities for further improvement of the routine or serious defects in it. Whether he can or not, he is likely to feel more friendly toward the new method if he has had the opportunity to criticize it. To a large extent he is estopped from criticism of the method after it has been placed in operation. When the standard practice has been modified to conform to any valid objections, it is submitted to the final authority for approval. When it has been finally approved, copies are sent to all executives who are affected by it and a copy is placed on permanent file. For purposes of control, a record should be kept of every copy that is issued.

In some cases, temporary standard practices are issued to correct practices which are radically wrong; for which some corrective measures must be applied immediately, pending a more careful analysis of the situation. It is understood that the temporary practice will be withdrawn as soon as the best method has been determined. Usually this course is taken only when an emergency must be met. It is not good policy to use temporary practices too frequently, for the reason that constant and frequent changes in methods are demoralizing to the organization inasmuch as it cannot always understand the reasons for them. Frequent changes prevent stability of system.

**Control of Standard Practices.** To get the best results, the control of standard practices should be placed in the hands of some one individual who should be responsible for their issue and recall and the maintenance of a master file of all standard practices which have ever been issued.

Usually when standard practices are approved, a serial number or symbol is assigned to them. To illustrate, "T21" might mean standard practice No. 21 on tool-department methods. If at some future time it should become necessary to revise the practice, the outstanding copies of "T21" would be recalled and the new practice bearing the symbol "T21A" would be issued.

A record must be kept of all outstanding standard practices, showing to whom they have been issued. Otherwise there is the danger

that when a practice is revised, all old copies may not be recalled. There is always the possibility that such copies may be the cause of misunderstandings and confusion.

In large organizations it is desirable that a periodic check be made of each standard practice to insure that the organization is living up to it. Unless this is done, the organization may slump back into the old routine.

**The Advantages of Standard-practice Instructions.** The standard practice has all of the advantages which have been previously noted for definite, complete, written instructions. In addition, they definitely locate the responsibility for the performance of each step in the routine. There is a minimum of danger that instructions will be lost and forgotten because each executive is held responsible for the instructions issued to him and is expected to keep his file intact. One of the great advantages of the standard practice is that it insures that the development of management methods will be continuously forward. There is little danger that we shall cover the same ground twice, for the reason that now we have a ready-reference file of decisions which have been made on the subject previously. Furthermore, this ready-reference file aids the executive materially in breaking in new employees. Their training is greatly facilitated.

**Causes of Failure of the Standard-practice Method.** Like many other devices of modern management, there are many instances of failure of the standard-practice method. In most instances the causes of these failures rest with the management rather than with the method. There are three common causes: (1) the issuing of too many orders or changes in practice; (2) poor preparation of standard practices; and (3) the feeling of the management that the method is too expensive. There have been instances in which the development of new methods has been a revolution rather than an evolution. The organization has been bombarded by a rapid fire of standard practices dealing with every conceivable phase of management. The personnel can hardly familiarize itself with one operating method before it is superseded by another. In such cases, the constant stream of standard practices is more likely to be a source of irritation than any real assistance to the organization. Well-considered changes in operating methods represent progress in the development of system and must be expected from time to time. However, the standard practice is an attempt to give to the organization the best method of performing a function or a particular phase of it. Therefore, it implies a reasonable degree of permanency.

The issue of too many standard practices may result from poor

preparation. It may be caused by the fact that the management does not realize the importance of proper preparation and delegates the work of developing standard practices to some one of mediocre ability. The prestige of the practice is affected adversely if it is prepared by some one whose competence can be questioned.

Obviously the first cost of making the standard practice is greater than the cost of issuing orders to the organization in verbal or typewritten form. The managements of many concerns feel that the execu-

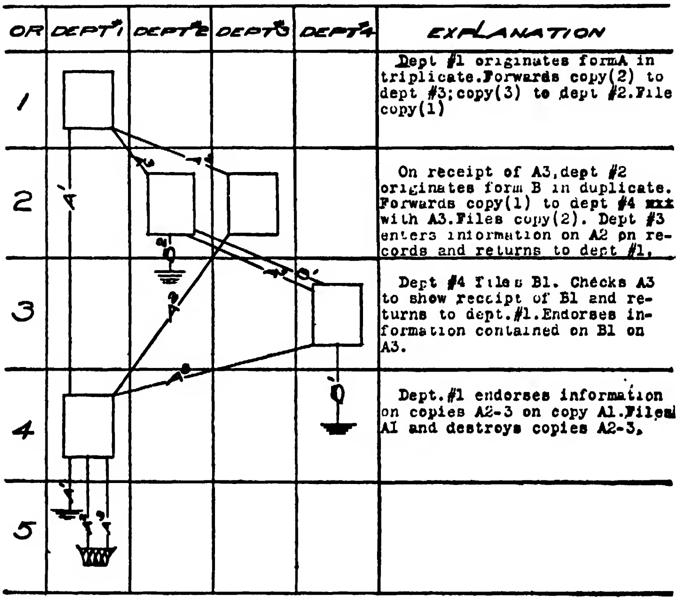



FIG. 15
THE ROUTINE SEQUENCE CHART

tives in charge of their departments are quite competent to develop satisfactory methods for handling the functions of these departments. It is quite likely that they are in most instances. It is unlikely that they can take sufficient time from the work of supervising their departments to permit them to work out the best methods thoroughly. In the majority of cases, the determination of the best way of handling a job will result in improved methods and the elimination of unnecessary operations which will more than offset the cost of preparation and maintenance of the standard practices.

**Routine Charts.** The function of the routine chart is to give a graphical analysis of a particular operating routine. It is often a helpful tool in the development of system. The more common types of charts

are the routine sequence type, the horizontal zone type, and the geographical type.

The routine sequence chart in Fig. 15 has the advantage that the sequence relation of the different operations is shown clearly. The movement of each form and the relation of its movement to the movements of other forms is readily apparent. The whole routine is spread out before the analyst with a brief explanation of each step. The significance of each step can be determined more easily than when the analyst must digest a great sheaf of data sheets.

In constructing the routine sequence chart the vertical columns may represent executives or work-places. In charting the assumed routine on the chart in Fig. 15, the vertical columns have been used to indicate the departments in which the various operations are performed. The horizontal zones on the chart indicate the steps in the routine. The vertical column at the right contains a brief explanation of each step. Detailed information concerning each step is contained in the body of the report on standard practice.

Any symbols may be used in constructing the chart. The following have been found to be convenient.

Action taken.

Irregular operation.

Forms destroyed.

File.

The letter indicates the form used in a given operation. The number indicates whether the copy is the original, duplicate, triplicate, etc.

The lines between the action squares indicate the movement of forms or materials. There is no need to draw arrows on the lines, as the action always works downward on the chart. The line for each copy of each form must terminate in some definite action. It is either filed or destroyed. If the chart has been correctly drawn, it will tend to close in the shape of a pyramid whose base is vertical. Steps which have been overlooked are readily seen.

In the horizontal zone type of chart, the course of each form is followed separately in the manner shown in Fig. 16. In each horizontal zone is plotted the course of a particular form. At the left of the chart are listed the various forms used in the routine. At the right of each

zone appears an explanation of the operations performed on the form. Any set of symbols may be used to indicate the more common types of action.

This type of chart has the advantage that the course of each form can be followed easily. Like the previous chart, it is easily made. It has the disadvantage that the sequence relation between the operations is not shown in the chart. Therefore the part played by each depart-

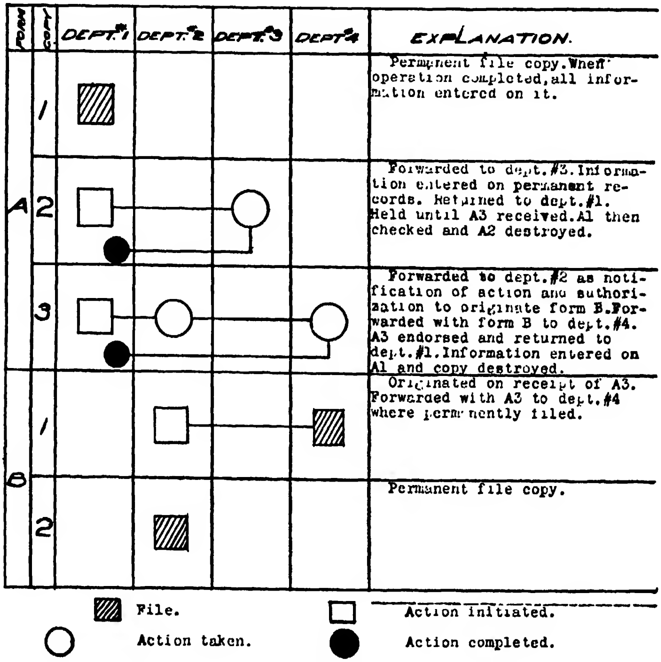



FIG. 16
THE HORIZONTAL ZONE ROUTINE CHART

ment or executive at each step cannot be seen except by studying the accompanying explanation. The routine shown in Fig. 16 is the same as that in Fig. 15.

In the geographical type of routine chart, an attempt is made to bring out both the sequences and the geographical relations of the operations. In constructing a chart of this kind, a conventional diagram of the office or shop layout may be used. In some cases, however, the various departments, work-places, or executives are merely indicated by large blocks properly labeled, with only general regard to their geographical relations. Small rectangles represent the forms. The lines indicating the movement of a form bear small arrow heads to

indicate the direction of travel. Small solid circles may be used to indicate the points of action.

The advantage claimed for this type of chart is that the geographical arrangement of the operations helps the person studying the chart to visualize the routine. When there are many forms to be used or operations performed, the large number of lines crossing and recrossing one another is confusing unless great care is taken in drawing the chart. Usually the office or shop layout is not simple. As the office or shop layout becomes more complicated, the difficulty of making a chart of this kind increases. In order to make it sufficiently clear to be easily understood, it should be drawn by a draftsman. As a result, it is more expensive to make than the first two types.

A type of routine chart which is somewhat similar in principle uses the forms themselves as the basis of the chart. Lines running from a given point on one form to some point on another indicate the transfer of information from the first to the second. A number on the line indicates the number of the operation. Arrows on the lines may be used to indicate the direction of the transfer. This type of chart also is relatively expensive to make.

The most satisfactory routine chart is one which can be constructed easily, quickly, and clearly without the aid of the drafting room. It should show the sequence relation of the various operations to one another. For most purposes, the routine sequence chart meets these requirements most satisfactorily.

# CHAPTER VIII

## THE ENGINEERING DEPARTMENT

**The Engineer.** The engineer has been defined as one who adapts the forces of nature to the uses of man. Industry is constantly employing forces which can be classified broadly as human and mechanical. Those problems which have to do with the efficient employment of human forces are, for the most part, problems of applied economics, and are the particular province of the operating executive. Those problems which have to do with the efficient employment of mechanical forces in the design and development of product and processes are, for the most part, problems of the applied mathematical, chemical, and physical sciences, and are the particular province of the engineer. However, it is often difficult to draw any clear-cut distinction between the work of the operating executive and the work of the engineer. As a result we sometimes find engineers solving problems which are primarily economic, and operating executives, having little engineering training, solving problems which are primarily engineering.

A distinction between the engineering and operating organizations can be drawn in a slightly different manner. Both may determine what shall be produced and how; the first with regard to the employment of mechanical forces, and the second with regard to the employment of economic forces. To illustrate, the operating organization may decide that 50,000 units of a particular product are to be made in January, 60,000 in February, etc. It may decide that certain parts which enter into the product are to be purchased, and that certain others are to be manufactured in the plant. The engineering department decides what parts are necessary for the proper functioning of the product, determines their design to insure this proper functioning, lays out and tools the various operations which must be performed on each part and the various assembly operations, and solves similar problems.

**The Chief Engineer.** In most organizations the chief engineer is a major executive. In the organization which we have set up as the basis of our discussion the chief engineer reports to the vice-president in charge of production. Instances will be found in which the engineering function is so important that the chief engineer may have the rank of vice-president, reporting directly to the president.

The chief engineer should have a peculiar and valuable combination of qualities. He should have a broad basic knowledge of science

and engineering. He should have a detailed knowledge of those engineering principles and practices which apply particularly to his industry. Considerable executive ability is of equal and sometimes of greater importance than the foregoing. The engineering function is a preparation function of the general function of production. Delays in the engineering department may delay the execution of the whole production program.

The following chart of the organization of the chief engineer is intended to bring out the various functions which may be found in the well-developed engineering department.

**The Engineering Organization.** The chief clerk is responsible for the proper handling of the paper work of the engineering department. He is directly in charge of the department's clerical force, and in many

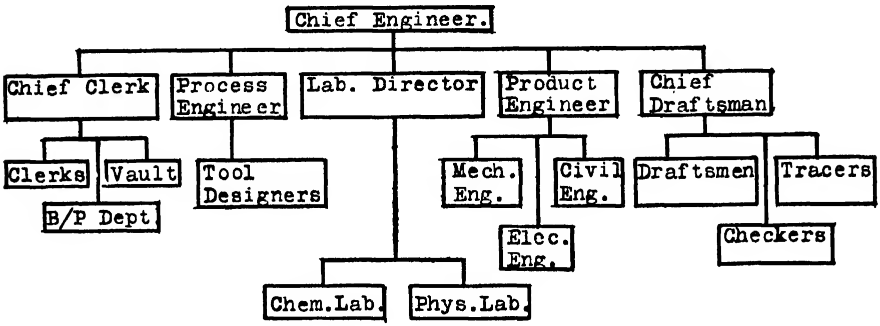



FIG. 17
THE ENGINEERING ORGANIZATION

cases the vault and blue-print departments because of the routine nature of their work. The engineering department of a large plant has a large amount of clerical work to do. Bills of material must be typed, change orders made out and issued, data and reports typed and recorded, and a host of other details attended to. In many respects, the chief clerk is the liaison officer between the engineering organization and the operating organization.

The control of the vault involves considerable responsibility. Often it contains data relating to valuable processes or patent rights. Usually the original designs of products and their parts, with subsequent revisions and tracings, are filed permanently in the vault. Very often a stock of blue prints for standard parts is carried in order that they may be issued to the shop without delay. It should not be possible to withdraw material from the vault except on requisition, approved by the chief engineer or other competent authority. Requisitions for blue prints are constantly being received from the shops. Blue prints which

are used continually soon become torn or illegible from grease and dirt. In large engineering departments, a number of blue-print machines may be in constant operation to meet this demand and to maintain the supply in the vault. The operation of this department is largely a routine matter and can properly be placed under the chief clerk.

The product engineer is responsible for the design and development of the product. If a committee system is in operation, his work may be under the general supervision of a product committee.[1] In any event, he must cooperate with the sales department in designing a product which will meet the needs of the public and at the same time meet the needs of economic production. Under the product engineer there may be a number of mechanical, civil, or electrical engineers, depending on the nature of the product and the size of the organization.

When the product engineer's staff has completed the product designs, the process engineer takes them and begins the processing of the product. He must determine what operations should be performed on each part, the various assembly operations, the tools which are required for each operation, the auxiliary equipment, and the devices for controlling the quality of the product. He should cooperate in this work with the production manager's and inspector's organizations. If the establishment were a metal-working plant, he might decide that operation 6 on a given part should be a milling operation, that a forming mill would be required, that a certain type of fixture is necessary for holding the work on the table of the milling machine, that a certain type of gauge is necessary to hold the dimensions of the cut within the limits established in cooperation with the inspection department. When the work has been laid out, the plans will be turned over to the tool designers, who will draw up the designs for the tools, dies, jigs, fixtures, and gauges.

The function of the chief draftsman is to relieve the engineers of as much of the detail, routine, engineering work as possible. When the engineers have completed their designs and they have been approved properly, draftsmen may make the empirical designs for any standard machine elements which go into the product. Tracers take the original drawings and make the tracings from which the blue prints are made. Checkers must check the tracings against the original drawings to insure that no errors have been made. This function involves a great amount of detail work. Unless the chief draftsman can get out the tracings promptly and in accordance with the demands of the production schedule, serious delays to production may result.

The laboratory director, or director of research as he is sometimes

[1] See p. 54.

called, conducts such experimental work as may be necessary for the development of product or processes. In addition he may test materials for the receiving department. Probably he will determine many material and product specifications. His work probably will bring him into frequent contact with the operating departments as well as the product engineer's organization. In large corporations, he may have a large organization of engineers, chemists, and physicists, and may be responsible for the expenditure of large sums. The director of laboratories is directly in charge of the chemical and physical laboratories.

The above organization would be possible only for a large plant. Nevertheless, the functions which have been indicated are present in the small organization to some degree. They are not so apparent because one engineer may have to handle a number of engineering functions.

**Planning and Scheduling in the Engineering Department.** The formal planning and scheduling of work in the engineering department is extremely difficult because of the lack of routine, repetitive work. It is almost impossible to establish any accurate relationship between time and output except in the most general terms. It has been attempted in some cases, but with no great amount of success.

While detail scheduling of engineering work may not be a practical proposition, some overall schedule of work is desirable and often is absolutely necessary. In the case of a new product, the actual work of production cannot start until the engineering department furnishes the blue prints and bills of material. One of the most frequent causes of delay is the failure of the engineering department to furnish them on schedule. If we merely establish for each part the approximate dates when the tracing should be completed, when the tooling should be finished, when the blue prints and bills of material should be issued to the shop, we have done much to eliminate such delays. It must be recognized that unforeseen difficulties may arise which may change the schedule considerably in individual cases. At least, the department has something definite against which it is working. In the above discussion, it is supposed that the designing and experimental work has been completed except for minor details.

As we have endeavored to show, the engineering department is the starting-point for much of the work of production, and as such is an important unit in the industrial organization.

# CHAPTER IX

## PRODUCTION CONTROL—FUNDAMENTAL CONSIDERATIONS

**The Meaning of Production Control.** Production control may be defined as the control of the order, extent, and manner of application of those factors entering directly into the production of goods. Babcock [1] defines production control as "that system which, extending over a long period of time, controls the order of movement of the elements of a productive program in relation to each other and to the whole." The three principal factors in production are men, materials, and machines. The control of the application of these factors to produce the most goods at the least cost consistent with the required degree of quality, the well-being of the workers and the requirements of promised deliveries is the function of production control. Production, as the term is generally used in industry, refers to the application of men and machines to materials.

A good control of these factors in production is most important. Before a production program can be executed sufficient man power must be secured. This man power must be suitable for the varied kinds of work which must be performed. It must be properly trained and supervised. Some control must be supplied to insure that it is used continuously, in so far as this is possible, and with the greatest economy. An adequate supply of materials of the right kind and quality must be secured and so controlled that it will flow to the job when needed. Machinery of the right kind, type, and capacity must be supplied and maintained in a condition which will permit it to operate constantly and efficiently. The application of these factors to one another at each step in the processes of production must be so controlled and coordinated that the work flows smoothly through them.

In addition to the interaction of these principal factors, it will be necessary to consider the effect of various phases of management which are either a part of or affect the work of production control. These include such problems as the analysis of the product, the control of material, the routing of the work through the shop, the scheduling of the work through the various steps in the process of production, the dispatching of orders, inspection, cost analysis, factory layout, equipment, product and process standardization, the development of an

[1] *Management's Handbook*, p. 579.

adequate tool supply, and many others. Some of these problems are of such major importance that they must be reserved for separate and more detailed discussion.

**Production Control Under Conventional Management.** Under the conventional type of management, the control of production rests in the line organization. There is little or no orderly, thorough pre-planning of production. The quantities to be processed are based either on the actual orders or the experience of the head of the production organization, who is usually the shop superintendent. Orders to process component parts or to assemble are issued to the shop when in the opinion of the superintendent or some assistant to whom the authority has been delegated the time is right. There are no records of the amount of shop capacity which has been absorbed by previous orders, and as a result there is no definite assurance, other than the knowledge the line executives gain by daily observation, that the necessary machines for any given operation will be open when the work arrives. In the small shop, the executive's personal knowledge of the condition of plant capacity may be sufficient. In the large plant, it usually is not. As a result, a frequent cause of delay is that work must be held up until machines become available.

Under the conventional type of management there is no formal scheduling of production. Usually the superintendent has under him a force of men, known as stock-chasers, whose duty is to follow the progress of the work through the plant and who are responsible for seeing that the work arrives at the assembly floor at the proper time to be assembled into the finished product. In some cases the orders for the individual parts for a given product are issued by the stock-chaser who is responsible for getting out production of that product. If it is a machine, the orders for the heavy parts, such as the base, frame, etc., are issued first when the experience of the stock-chaser tells him that they should be if the machine is to be completed and shipped as promised. The smaller parts which can be produced in a relatively short time are issued later at his discretion. In most instances there is no difficulty in connection with the major machine elements. They are so important that any interference with their production is immediately noticed and removed. The smaller parts often cause the delay. Because they are small and produced with relative ease, their progress is not followed so closely and in some instances they may be overlooked entirely. As a result, the assembly of the machine may be held up because of the failure of some small part to arrive at the proper time and quite as effectively as though the base or frame were not on hand.

If assembly is delayed beyond the promised shipping date, pressure is exerted on the production organization by the sales department.

As a result, the stock-chaser goes into the shop to speed up the progress of parts which have failed to arrive at the assembly floor on time. Often the stock-chaser will personally follow the progress of delinquent parts through the shop. Current production is set aside and the delayed work is placed in the machines. There is delay while the old set-up is torn down and the machine is reset for the new job. In addition, there is the extra expense of set-ups. The rhythm of production is broken and there is a loss of morale resulting from the evident inefficiency of the production organization. Furthermore, when work is put through the shop under pressure, there is always the danger that the quality of the product may suffer.

While the orders for the various parts may be issued by the superintendent or the stock-chasers, the starting of the operations on a part often rests with the foreman. In starting the operations, a foreman is influenced more by the convenient distribution of the load on his department than by the relations of the parts to one another from the standpoint of final assembly. It can hardly be otherwise, as he has not a complete picture of the production situation. The two viewpoints may be quite different, resulting in delay in the final assembly. Furthermore, he may be affected by the aggressiveness of the different stock-chasers.

In some plants, hardly 50 per cent of the promise dates made to customers are kept. Often when the order is not shipped as promised, the delay interferes with the customer's own production program, causing him to be greatly inconvenienced. The resulting dissatisfaction may cause the loss of the customer's business. One of the best assets of a plant is a reputation for keeping promise dates.

This is only a partial summary of the losses which may occur from poor production control. Usually there are many others resulting from poor correlation of the tool supply with the needs of the shop, the failure of material to arrive at the starting operations on time due to poor material control, lack of standardization of materials and methods, and many others.

**Production Control Under Scientific Management.** Under scientific management, we employ the methods of scientific analysis in the solution of our management problems. Taylor defined the art of management as "knowing exactly what you want men to do, and seeing that they do it in the best and cheapest way." [1] Our problem then is to find the one best method of performing and controlling each production function.

In studying production control in a plant operating under scientific management, one of the first developments which attract our attention

[1] *Shop Management*, Frederick W. Taylor, p. 21.

is the planning department. It has been introduced as the result of a realization of the need of a policy of anticipation in production control rather than a policy of drift and check-up which characterizes production control under conventional or systematic management. The desirability of employing specialists for the efficient performance of the various functions of production control has been seen.

Production is preplanned, and each step in connection with it is controlled. The organization of the planning department and the scope of its activities will vary between organizations. In some cases it may operate largely as a staff organization. In others, the whole organization may be highly functionalized, in which case the line organization largely disappears. There is a system of production orders. The opening and closing of all production orders is closely controlled by the planning department. In order to control production, an effective control of materials is necessary. Material control is either under production control or closely coordinated with it. The planning department directly controls manufacturing orders, the machinery, equipment, and work-places, the routing of orders, and the movement of all work in the shop. In some instances it may even control directly the assignment of jobs to workmen.

As far as possible, the records and standards which are used in preplanning production are based on scientific investigation and analysis rather than on past performances. To illustrate, the time required to process a standard number of parts on a given operation now is determined by methods of time and motion study rather than by records of past production. There are complete records of standard routings for standard parts and processes. The best sequence of operations is worked out, together with the departments in which the work should be done and the equipment which should be used for each operation. The shop is held to the standard routing unless some emergency arises which warrants deviation from it, in which case proper authorization for such deviation must be obtained from the planning department. Other illustrations might be given to show that facts obtained by rational analysis of production problems have been substituted for guesses based on personal experience.

The scheduling of work through the plant is developed to a much higher degree than is possible under the more elementary types of management. Inasmuch as the planning department has complete information relating to the production of the product, it can determine accurately the time when each operation on a given part or product should start and stop. As the best method of processing the product has been determined, it can indicate to the shop the class of equipment which should be used on each operation. In some cases there are

records of the capacity of each class of equipment available at any time, so that the department can determine whether the operations can be performed on the equipment indicated, at the scheduled times. Undoubtedly, methods have been developed and a system of reports introduced, which will show at any time the location of an order in the shop and the relation of its actual to its scheduled progress. The dispatching of orders to the shop is developed to bring the movement of work through the shop under the control of the planning department.

Inasmuch as the work of material control affects directly the work of production control, undoubtedly it has been developed to a relatively high degree. Purchasing is coordinated more closely with the requirements of production, probably through the stores records. Furthermore, these records will be coordinated more closely with the actual inventories under the control of the stores department. In order to aid the work of planning, they will show the amount of each item of material which has been apportioned against orders which have been previously planned, and the amount available for apportionment against future orders. The maximum amount of each item of material to be ordered at any one time, and the minimum to which such stores can fall before orders for new stock are placed, are determined. All materials are standardized as to kind and quality to insure that materials are used which best meet the requirements of the product and that inventories will not be built up unduly as the result of the addition of items which are seldom used or whose uses are covered by other items regularly carried in stores. Detailed specifications covering the characteristics of each item carried in stores are written to insure the procurement of the right kind and quality of material by the purchasing department. Similarly in connection with each of the phases of material control, methods developed as the result of scientific analysis of the problems of material organization and control have been substituted for rule-of-thumb methods based on personal experience.

To the same degree, the personnel, engineering, and maintenance functions which serve the function of production will be placed on a scientific basis and coordinated with the work of production control. Costs which under conventional or systematic management are largely historical are developed to furnish reports which will indicate current manufacturing conditions and to this extent assist in the work of production control.

**The Organization of the Production Department.** The general characteristics of the production division have already been discussed. The characteristics of the production manager's organization will vary with each concern to suit its particular production problems. Executive nomenclature is not standard, so it is natural to find that the titles of

executives, as well as their duties, also will vary. In order to give some concrete idea of the organization of the production department, an organization has been set up which is fairly typical, particularly with regard to the functions performed by the more fully developed departments. It must be remembered that in small plants it is necessary to combine functions. In large plants, the reverse may be true. Therefore the organization which has been shown in Fig. 18 is of value chiefly for illustrative purposes. It would be necessary to modify it to suit the conditions in any given plant.

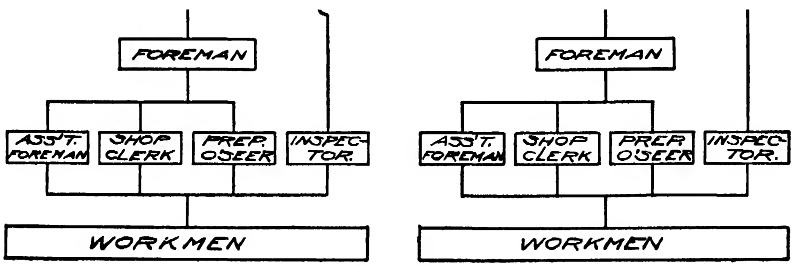



FIG. 18
THE PRODUCTION MANAGER'S ORGANIZATION

The production manager is a major executive, reporting to the vice-president in charge of production. The two principal functions for which he is responsible are (1) the control and (2) the execution of production. Accordingly, there are two executives reporting to him—the planning supervisor who is directly in charge of the control function, and the shop superintendent who is directly in charge of the execution function.

Under the direction of the production manager, the planning supervisor determines what shall be manufactured, when and how, with due regard for engineering standards and any general manufacturing pro-

gram which may have been established. He is responsible for the work of planning, routing, scheduling, preparation, and dispatching. Where the plant has no methods manager, the work of developing the production-control methods of the plant will fall largely on him. His job calls for a good analytical mind, considerable experience with the operation of production-control methods and preferably with their installation, ability to supervise a large amount of detail, and a good practical knowledge of the plant, the products, and their processes. Reporting to him are the chief preparation clerk, the chief planning clerk, and the chief scheduling clerk.

The function of planning is to determine what shall be done and how it shall be accomplished. In the exercise of this function in connection with production-control, the chief planning clerk analyzes the manufacturing orders, with the aid of the planning records or information submitted by the sales or engineering departments, in order to determine the operations which must be performed, the proper routing of the work, the tool, equipment, and material requirements, the process time and other data. He writes the various papers used in initiating and controlling production.

The function of scheduling is to determine when or at what rate the various operations shall be performed and the events in the manufacture of a product shall occur. With proper regard for the production program, if the company is manufacturing to stock or the promise date on the sales order if it is manufacturing to the customers order, the scheduling clerk determines the date when each operation on each part should start and finish. In this connection, he must have or be supplied with information concerning the time required to process each operation and move the work. He must take into account the probable availability of productive capacity at the time when each operation is scheduled to start. He operates the devices in use for checking and controlling the progress of the work through the shop. For this purpose he receives reports from the shop indicating such progress. He is also responsible for originating reports to the planning supervisor indicating the status of work in the shop. In a large organization he may have a force of schedule clerks, load clerks, and dispatchers reporting to him.

In those concerns in which it is necessary to control the progress of each order through the plant, there may be one or more load clerks whose function is to control the load of work ahead of each group or class of machines. The load clerks maintain records of machine capacity which show for each group or class of machines or work-places, and in some instances for each machine or work-place, the amount of machine capacity which has been apportioned against out-

standing or planned orders during any future period and how much is available for apportionment against new orders. In those concerns in which control is based largely on the maintenance of a predetermined rate of flow from each operation, such capacity records may not be necessary as will be shown later.

The dispatch clerks are concerned with the starting of the various operations on orders in the shop. They forward the production papers to the shop and control the performance of the individual operations with regard for the schedule.

When interferences to production develop which cannot be handled by the shop, they report them to the chief preparation clerk. The function of preparation is to insure that the work can be done as planned by anticipating and removing impending interruptions to production. In this connection, the chief preparation clerk receives the production papers from the chief scheduling clerk and checks them with regard to the probable availability of materials, tools, and equipment. In addition, he may be responsible for the prompt removal of any interruption to production which may arise after the order has been placed in production and which cannot be handled effectively by the department in which it arises. In some instances, he may place and follow up tool orders.

In the production manager's organization, the function of production consists of the actual processing of the work in accordance with the plans and schedules which have been worked out by the planning department. It is performed directly under the supervision of the shop superintendent. His function is to coordinate the work of the shop departments in order that they may meet these plans and schedules. He cooperates with the preparation clerk in the removal of interferences to production, removes any friction which may develop between shop foremen. He is interested with the production engineers in the development of shop processes. He should be technically trained or have a broad mechanical experience and should possess an intensive knowledge of the shop practice of his particular industry. Combined with this there must be considerable executive ability. The foremen in charge of the various shops report to the shop superintendent.

The foreman is in charge of production in a particular shop department or group of departments. He is responsible for the execution of the plans and schedules of the planning department in so far as they relate to the operations performed within his department. The modern conception of the foreman is that of a leader of his men, a teacher who trains them in the best methods of performing their operations as determined by time and motion study, a remover of interferences to production which arise within the shop, and an execu-

tive who sees that the work in his department is completed in accordance with the plans and schedules of the planning department. Under scientific management, he is relieved of the routine work of planning, scheduling, preparation, and following the progress of work in his shop, and is therefore free to perform his real functions.

The assistant foreman relieves the foreman of such work as may be assigned to him. In the illustrative organization, his chief duty would be that of an instructor. While his function is not the same, it is similar to that of the speed boss in the Taylor organization.

The shop clerk does the routine planning and scheduling of the work in the shop. Under the supervision of the foreman, but in accordance with the plans and schedules of the planning department, the shop clerk assigns the work to the employees, operates whatever devices may be used for controlling production in the shop, and makes such reports to the planning department concerning production in the shop as may be necessary. As far as the general methods employed in controlling production in the shops are concerned, the shop clerks are under the authority of the planning supervisor. In matters of discipline and the day-to-day performance of their duties, they are under the authority of the shop foreman. This arrangement insures closer coordination of the functions performed in the shop, better discipline, and more whole-hearted support from the foremen inasmuch as their position is not weakened. At the same time, it insures that the best methods of controlling production in the shop will be used uniformly in each shop throughout the plant. It will be noted that the organization which has been set up calls for a form of decentralized planning. Under centralized planning, most of the work of the shop clerk would be taken into the planning-room from which the work of each shop would be controlled. The question of centralized and decentralized planning will be discussed later.

The preparation overseer performs the preparation functions in connection with production in the shop. In some cases, he may requisition the material for orders to be started in his shop. He checks the receipt of worked material from preceding operations in other departments to determine its availability for the operations to be performed in his department. In some shops he withdraws the tools required for an operation from the shop tool cage and moves them with the material to the machine or work-place where the operation is to be performed. He moves the work from the machine to the inspector. The function which he performs is similar to that performed by the gang boss in the Taylor organization. In connection with the general method of performing his function, he is under the authority of the planning supervisor. In matters of discipline and the day-to-day per-

formance of his duties he is under the supervision of the shop foreman. The shop movemen report to him.

The inspector supervises the quality of the work done in the department. He does not report to the shop foreman, but directly to the chief inspector.

**Fundamental Principles and Axioms Affecting Production Control.** In addition to the considerations underlying the development of good organization and system, there are certain fundamental principles of management which directly affect the control of production. The following statement of these principles is either taken directly or adapted from a statement by Mr. L. P. Alford:[1]

(1) *The Law of Simplification or Specialization of Product.*

*Concentrating upon the manufacture of a single or a few types and sizes of product tends to improve the quality and lower the production cost.* When this is done, larger lots of material usually can be run through the machines before it is necessary to close them down and readjust them for the processing of a different type or size of product. In most cases there is a steadier, more uniform flow of work through the plant, which makes possible greater rhythm of production and greater ease of control, with consequent reductions in unit costs. The standardization of materials, product, processes, and methods of control can be developed to a higher degree than would otherwise be possible. For these and other reasons, product simplification tends to improve quality and lower unit costs.

(2) *The Law of Product Standardization.*

*Determining and fixing the best types, sizes, and characteristics of the product reduce the cost of its manufacture.*

*Corollary: Interchangeable manufacture reduces manufacturing cost and, all other characteristics being equal, produces a product of maximum serviceability.*

The effectiveness of preplanning depends greatly on the extent and accuracy of the available information relating to the characteristics of the product.

(3) *The Laws of Economic Production.*

*The unit cost of production decreases when the rate of increase in output increases faster than the rate of input or use of the production factors.*

*The unit cost of production increases when the rate of increase in output increases at a lower rate than the rate of input or use of the production factors.*

While certain factors in the unit cost of the product tend to in-

[1] "Laws of Manufacturing Management," by L. P. Alford. A paper presented to the American Society of Mechanical Engineers, December 6–9, 1926.

crease directly as output increases, such as direct material and labor costs, certain factors do not, such as rent, insurance, and taxes.

(4) *The Laws of Mass Production.*

*Large-scale production tends to increase operating efficiency and competitive power.*

*In large-scale production the unit time of production tends to approach the actual operating time as a limit.*

Usually, the large-scale producer has a more effective control of production. In general, it is easier to operate control methods based on the control of a flow of production than to operate those based on the control of the movement of individual orders. Furthermore, the large-scale producer is able to employ executives of greater ability and experience. He is able to develop a larger and more accurate body of information relating to product and processes on which the preplanning of production can be based. He can develop the division of labor to a higher degree with increased individual efficiency. He can employ economically a larger percentage of single-purpose machinery. Inventories are relatively smaller. The turnover of work in process is faster due to the more effective preplanning of production and the use of more and better material-handling equipment. He can employ scientists to conduct research in the development of better products and processes. Because of his size, the high caliber of his organization, and the favorable publicity which often attends his research work, he enjoys favorable prestige with the public which gives him a material competitive advantage.

(5) *The Law of Production Control.*

*The highest efficiency in production is obtained by producing the required quantity of product, of the required quality, at the required time, by the best and cheapest method.*

To the above statement might be added, "*in the shortest practicable time.*" It does not follow necessarily that because goods of the right quality and quantity are received at the right time, the best and cheapest methods have been applied in the most effective manner. This can only be assured by the development of effective control methods, supplemented by proper incentives.

(6) *The Law of Planning.*

*The mental labor of production is reduced to a minimum by planning before the work is started, what work shall be done, how the work shall be done, where the work shall be done and when the work shall be done.*

To the above statement might be added, "*and by insuring that the work can be done as planned.*" Unless the preparation function is exercised, the other work of planning may be largely nullified. The

preplanning of production should insure that the work will be processed in the best possible manner with a minimum of interruptions. It relieves the shop organization of many duties which it is poorly equipped to perform.

(7) *The Law of Quality Control.*

*Control of quality tends to increase the output of saleable goods, decrease the costs of production and distribution, and facilitates economic mass production.*

The effective control of quality requires an intelligent study of methods of work and causes of scrap. Quality control and standards result in more dependable quality. As a result of such study, methods of manufacturing are developed to maintain the quality standards without increasing costs.

(8) *The Law of Economic Lot Size.*

*The quanity of product that can be manufactured at lowest unit cost varies directly as the square root of the preparation costs and inversely as the square root of the interest charge and the storage charge.*

There is a certain part of the cost of production, such as the cost of the engineering work, the preplanning of production, and the setting up and adjustment of machinery, which does not vary greatly with the quantity produced. Therefore, the greater the quantity produced at a single run, the lower will be the unit preparation cost of production. However, if the quantity produced is too great, the period of time required for its consumption will be so great that the interest and storage charges will more than offset the savings from reduced preparation charges.

In addition to the above, the following principles are so important that they might well be stated as laws.

(9) *The Law of Material Control.*

*An adequate control of materials is a prerequisite for the effective control of production.*

Without such control, there is always the danger that materials of the right kind and quality may not be present in the right quantities when needed.

(10) *The Law of Operating Standards.*

*Adequate operating standards are essential to the efficient control of manufacturing.*

Without such standards, production cannot be preplanned or controlled effectively. There are no yardsticks by which the degree of perfection in performance can be determined. The degree of accuracy and refinement to which operating standards are developed depends largely on the requirements of the particular business. In some cases,

they may be estimated. In others, they may be the result of extensive research.

**Factors Affecting Production Control.** The principal factors affecting production control are:

(1) Adequate planning records
(2) Planning and routing,
(3) Scheduling
(4) Material control
(5) Tool control
(6) Dispatching
(7) The control of time
(8) Cost control
(9) Quality control
(10) Equipment control
(11) The method and extent of control
(12) The organization for control.

The extent to which satisfactory production control can be developed depends to a considerable degree on the extent to which adequate planning records are available. The planning records are the result of an analysis of the product and the processes from the standpoint of production. They may be either current or permanent, depending on the characteristics of the production problem. If the concern is manufacturing strictly to the customer's specifications, the records for the most part will be current, consisting chiefly of a bill of material furnished to the planning department by the engineering department, with supplementary information relating to operations, operating times, machines and equipment. If the concern is manufacturing continuously to stock, the product probably will be highly standardized and the information will be taken directly from a permanent record on file in the planning department. In an engineering industry, such information would be obtained originally from the engineering department. Obviously, planning, routing, and scheduling can be done effectively only to the extent to which sufficiently accurate planning records are available.

The function of planning has been defined as the determining of what shall be done and how it shall be accomplished. Routing is the function of determining where the work shall be done. In the majority of cases, the exercise of these functions is largely a matter of routine clerical work. The necessary information is furnished to the planning clerks by the permanent planning records or by the sales, engineering, and production executives. On the basis of such information, the planning clerks write the various production papers which tell the production organization of what material the product is made and how much is required, what operations are performed on

each part, how they are performed, the unit time required for the performance of each operation, the class of machine to be used, the department in which the operation should be performed, the tools and equipment required for each operation, and similar information.

The function of scheduling has been defined as the determining of when or at what rate the various operations shall be performed and the events in the manufacture of the product shall occur. In the case of manufacture to order, the scheduling clerks determine, on the basis of the information contained in the production papers, when each operation on each part or product should start and finish. The nature of the work of scheduling already has been indicated on page 105.

Material control is concerned with the work of procuring materials and their receipt, storage, issue, movement, and salvage, together with the control of inventories. Modern planning methods require that the availability of all materials required for an order be known before the order is released to the shop. Otherwise it may be held up at the starting or subsequent operations because of the failure of materials of the right kind and quality to arrive at the scheduled time for starting the operation. Delays to production are costly.

Similarly, an adequate supply of the right tools must be available at the right time. In the average shop the failure of the tool supply is a frequent cause of delay. Where tools are consumed regularly in the course of production, the supply may become exhausted because of poor tool control. Where special tools must be produced or purchased, they may not be on hand when the operation for which they are intended is scheduled to start. In a great many plants, the control of production in the tool department is poor. As a result, a high percentage of the promise dates on tool orders are broken. As previously stated, the function of initiating and following up tool orders may be one of the functions of the preparation section of the planning department.

Dispatching is the function of releasing authority for the performance of directly productive operations. Accordingly, the dispatch clerks release various production papers to the shop in accordance with the time schedule. They receive from the shops various production papers, such as operation tickets and production orders which have been closed out, which indicate the status of work.

Closely related to the work of scheduling and dispatching is the control of time. There must be a proper record and control of operative's attendance. In many cases, schedules may be interrupted seriously unless the planning department receives notice of the absence of workmen within a reasonable period after the beginning of the work period. It may be necessary to shift work to other machines.

Furthermore, a close control of operating time is advisable. In many plants, the relation between the standard time for performing a given operation and the actual time taken is the basis of wage payment. Reports of the completion of operations with the time taken for their performance often are necessary for controlling production, particularly when the progress of individual orders is being followed. It was Taylor's experience that in many cases neither the management nor the men have an accurate knowledge of the best method of performing a given operation and the exact time which should be taken to perform it. The essence of scientific management is the determination of the one best way of performing a given function. In connection with production, the technique of time and motion study has been developed for determining the best equipment, tools, method of performance for an operation, and the time required to perform it.

Good cost control may assist production control by making possible comparative reports indicating operations having excessive scrap or other costs, which offer opportunities for study with a view to developing greater operating efficiency.

In connection with the control of quality, the inspection organization is engaged in comparing the actual quality produced with the standards of quality. One of its functions is to assist in reducing scrap, thereby making possible more accurate production control. In the case of an assembled product, the control of quality makes the work of assembly easier, quicker, and cheaper. Control of the quality of materials entering into the product not only improves its quality, but makes possible greater and more uniform production.

An adequate control of equipment is vital to an effective control of production. Unless the machinery is arranged to the best advantage, the greatest economy in the movement of materials and work in process and the most rapid turnover of working capital are not possible. Unless it is properly maintained, machine break-downs may seriously interfere with the fulfillment of the production schedule. Furthermore, the standardization of equipment facilitates the control of production. If such factors as power, strength, rigidity, feeds, and speeds are the same for all machines of a given class, the correct method and time for a given operation can be determined and the job put on any machine in the proper class which may be open at the time when the operation is scheduled to start. If such factors are not the same for all machines in a given class, the job must wait until the particular machine on which the operation was set becomes available. Obviously, such condition increases the difficulty of making workable schedules.

The method of control must be designed to meet the needs of the

particular manufacturing problem. The general basis of control in one industry may be quite different from that in another. In fact, plants within the same industry often differ sufficiently from one another to make it necessary to develop control methods to meet the needs of the particular plant. The control methods should include control of all of the factors in production. Otherwise the uncontrolled variation of some of them may make it difficult if not impossible to make and maintain production schedules and a smooth flow of work through the plant.

The importance of a good organization for production control is obvious. Some of the more important characteristics of the production organization have been discussed previously.

**Types of Industry and Production Control.** The problem of controlling production also is affected by the type of industry in which the control is to be introduced. There are two general types—(1) assembly industries and (2) process industries. In an assembly industry a number of component parts are assembled together to make the finished product. Each part passes through a series of operations which in most cases is peculiar to itself. The manufacture of each part proceeds independently except that all parts must be completed at the proper time for assembly into sub-assemblies or the finished product in accordance with the schedule. In some operations it may be necessary to process two or more components together. The materials from which the various components are manufactured may be the same or very different. The machine-tool industry is an example of this type. Fig. 35 is a manufacturing diagram for an assembled product.

In the process type, the basic material or materials are worked through a series of operations into the finished product. The character of the materials may be changed radically as a result of these operations. Usually the individual identity of the materials is lost in the product. The cement industry is an example of a process industry. Furthermore, such industries may be classified as synthetical or analytical. In the synthetical industry, the materials are combined through various processes and worked into the finished product. Fig. 20 indicates that materials A, B, and C are brought together and put through operation 1. Material D is added at the start of operation 3. The combined materials are then put through operations 3 and 4 to make the finished product E. The manufacture of pig iron is a synthetical, process industry. In the analytical process industry, one or more basic materials are broken down by means of various processes to make certain by-products and the ultimate product. In the hypothetical case illustrated in Fig. 19, some basic material A is worked through

operations 1, 2, 3, and 4. During operation 4, by-product B is drawn off. This by-product also may be carried through a series of operations before it is worked into its final form. Similarly, by-product C is drawn off during operation 5, by-product D during operation 6, and the remainder is put through operation 7 to make the ultimate product E. The by-product coke industry is an example of an analytical process industry.

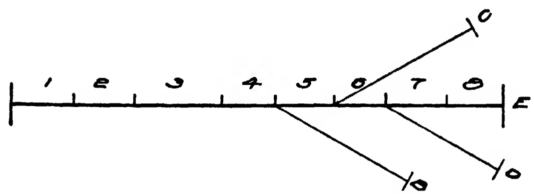


FIG. 19
THE ANALYTICAL PROCESS TYPE

In general, the assembly industry bases its control methods on the control of the progress of individual orders or lots. However, when an assembly industry manufactures a highly standardized product in large quantities, the production-control problems often resemble closely those of the process industry. In general, the process industry bases its control methods on the control of the flow of work from the various operations.

It is obvious that the methods in use in one type of industry will vary considerably from those in use in another. As previously pointed

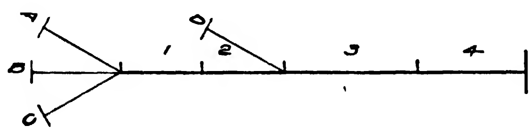


FIG. 20
THE SYNTHETICAL PROCESS TYPE

out, there usually are enough differences in product, personnel, and equipment between two plants in the same industry to make it inadvisable to introduce the production methods of the one plant into the other plant in their entirety. In some instances, management consultants have developed certain control methods which they have attempted to introduce with little modification in a wide range of industries. In many cases, these methods have failed or have not produced the savings that were anticipated. The above discussion gives a partial explanation of such failures.

In considering the relation of the type of industry to the development of production control methods, it should be remembered that between the pure assembly industry and the pure process industry, there is a wide range of industries which approach the one or the other extreme with varying degrees of closeness.

**Types of Manufacturing.** Manufacturing operations can be classified as (1) intermittent manufacturing, (2) continuous manufacturing, and (3) variants of the two preceding types. Intermittent manufacturing may be defined as that type of manufacturing in which labor and equipment are applied continuously to materials in the manufacture of a given part or product for a relatively limited period. Usually, plans are made, material and tools procured, machinery set up and adjusted, for a specific order or lot of product. A relatively short time is required for the completion of any given operation on a part or product. When it has been completed, the set-up is dismantled and the machine reset and adjusted for an operation on another part or product which may be quite different. Continuous manufacturing may be defined as that type of manufacturing in which labor and equipment are applied continuously to materials in the manufacture of a given part or product for an extended period. Usually, plans are made, materials and tools procured, and machinery set up and adjusted to produce and supply continuously a large quantity of parts or products to the storeroom or the assembly floor over a considerable length of time. Once a machine has been placed in production for an operation on a given part, it may run on this operation for many months, except for occasional shutdowns for readjustment or the replacement of worn tools or equipment. In industries which have developed mass production to a high degree, many machines may run year after year on the same operation until there is some change in the design of the product or the method of processing. Many concerns have conditions of manufacturing which are variants of the above basic types.

**Types of Production Control.** The types of production control are (1) the order control type, (2) the flow control type, and (3) variants or combinations of the preceding types. In the first type, the methods are based on the control of the progress of the order through the various operations which must be performed on it. As indicated in Fig. 21 each order must arrive at the right department and work center at the right time to permit certain specified operations to be performed on it in accordance with the time schedule. Sufficient machine capacity of the right kind must be available when the work arrives. Tools and materials must be on hand. The control methods must indicate the status and location of the order at all times, and the progress that it is making in relation to the time schedule. In the

second type, the methods are based on the maintenance of a predetermined rate of flow of work from each machine or work center. The cross-hatched areas in Fig. 22 represent this flow. As indicated in

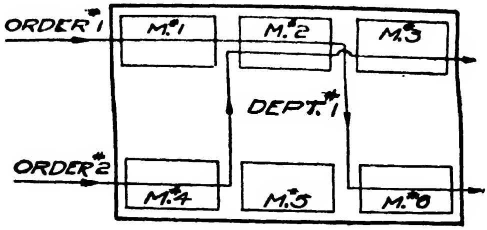



FIG. 21
ORDER CONTROL DIAGRAM

Fig. 22, the materials and work in process must flow to and from the machines at a fairly constant rate. To attain this condition, the machine capacity applied on each operation must be properly balanced. Often the rate of consumption of tools is determined and an adequate supply kept on hand in the shop tool cage at all times. The control methods must indicate, at all times, the current and cumulative quantities produced on each operation and their relation to the scheduled rate of flow.

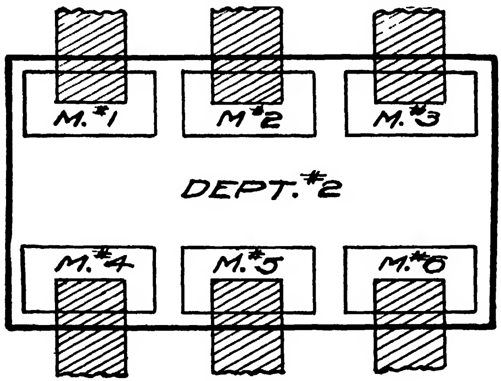



FIG. 22
FLOW CONTROL DIAGRAM

In the above discussion, a work center is any area in the shop containing like machines or producing a particular class or kind of work which has been designated as a work center. It may include one or more machines with the necessary space for the workman and the storage of materials and work coming to and from the machines. Its size and characteristics are determined by the characteristics of the production problem to a large extent.

# CHAPTER X

## PLANNING, ROUTING AND SCHEDULING

**The Determination of the Probable Demand for the Product.** The extent to which the probable demand for the product can be determined depends largely on the nature of the product, its demand, and the extent to which organization and system have been developed. A process industry manufacturing continuously a highly standardized product can forecast its demand to a considerable degree if it has well-developed performance standards, adequate records, a good system of operating reports, and competent statistical and budget departments. A highly intermittent assembly industry manufacturing largely to order cannot forecast its demand to the same extent. For the most part, it must accept the demand as it arises. Obviously the first industry can develop a more effective control of production than the second, because of its greater ability to anticipate and prepare for the demand for its product and to apply certain measures which will indicate the extent to which the plant will meet it.

The more progressive concerns, particularly those making large quantities of standard products, maintain statistical departments, engaged in determining the probable effect on the demand for the products, of those economic forces which affect business in general, those which affect their particular industry, and those which have their origin in the business itself. Such departments regularly collect and analyze a wide variety of business statistics which indicate the extent and trend of these forces. As business becomes more complex, such information becomes more necessary because economic forces do not act independently but interact upon one another. Low farm prices or extensive crop failures may reduce the purchasing power of a large part of the agricultural population, which in turn may affect adversely the business of the mail-order concerns. Even when external conditions are good, certain conditions within a particular mail-order concern may prevent it from making money.

From an analysis of statistics relating to general business, the industry and the company's business, aided by reports and estimates of probable conditions and sales in different sales territories, the statistical department determines what the sales during a forthcoming period probably will be. This forecast of sales usually must be submitted

June 3, 1927

F. B. Calhoun, Mgr.,
Production Control Div.

PNEUMATIC TIRE ESTIMATE FOR JULY & AUG.
TOTALLING 50,000 DAILY (Plant #2 - 27,000)
(Plant #1 - 23,000)

| Size & Type | Mfrs. | Branch | Total |
|---|---|---|---|
| CLINCHER FABRIC | | | |
| 30x3 A.W.T. | | 200 | 200 |
| 30x3½ " | | 100 | 100 |
| 30x3 Path. | | 300 | 300 |
| 30x3½ " | | 100 | 100 |
| TOTAL | | 700 | 700 |
| CLINCHER CORD | | | |
| 30x3½ AWT (3.70) | | 1500 | 1500 |
| 30x3½ " (3.85) 4 ply | | 2986 | 2986 |
| 30x3½ " " H. D. | | 590 | 590 |
| 30x3½ Path. (3.50) | | 2920 | 2920 |
| 30x3½ " (3.85) | | 1080 | 1080 |
| 31x4.40 AWT H.D. | | 215 | 215 |
| 30x3 AWT | | 165 | 165 |
| 30x3½ AWT (3.42) | | 200 | 200 |
| 30x3 Path. | | 100 | 100 |
| TOTAL | | 9756 | 9756 |
| MOTORCYCLE AWT | | | |
| 28x3 Fabric | | 300 only | 300 only |
| 27x3½ " | | 300 " | 300 " |
| 29x3½ " | | 50 " | 50 " |
| 25x3.85 Cord | 50 | 25 | 75 |
| 26x3.30 " | 50 | | 50 |
| 27x3.85 " | 100 | 100 | 200 |
| TOTAL | 200 | 125 | 325 |
| 30x3½ Clin. Cord Standard #1 | | 100 | 100 |
| 710 x 90 Metric | | 20 | 20 |
| 700x80 " | | 20 | 20 |
| TOTAL | | 40 | 40 |

*Courtesy—Goodyear Tire and Rubber Co.*

FIG. 23
A PRODUCTION PROGRAM

to some committee, such as the production committee previously described,[1] for final approval. Such a committee is responsible for the determination of what shall be produced and sold, how much and when. In it, the views of the sales, production, and financial organizations must be harmonized. The sales organization naturally wishes to sell those lines which have the least sales resistance. The production organization wants to make those lines which give the best balanced production program and which can be handled with the greatest ease in the shop. The financial organization is naturally conservative with regard to expansion or changes in policy which involve the expenditure of considerable sums. It is interested in the sales and production programs because it must finance them. Obviously, in working out the details of the sales and production programs, there are many factors which must be considered, such as seasonal variations in demand, the amount and kind of plant capacity available, the most economical quantities to manufacture, the availability of materials, storage capacity, and many others.

On the basis of the sales program, the production organization will make up a production program for the period under consideration. In most cases, it would be made by the planning department subject to the approval of the head of the production organization and the production committee, if there is one. The production program is a forecast by weeks or months of the production of each item of product that probably will be needed to meet the requirements of the sales program. Its purposes are to make possible greater effectiveness in preplanning production and to set up performance standards against which actual performance can be checked. It has the following advantages: (1) it permits a more efficient use of plant capacity; (2) it usually results in less labor turnover; (3) it makes possible more effective preparation; (4) working capital is used more effectively; (5) relatively smaller inventories or raw materials and work-in-process usually are possible; (6) because the foregoing result in better management, it aids in reducing costs and increasing profits; and (7) the anticipation of sales demand makes possible more prompt deliveries to customers.

If there is a budget department, copies of the sales and production programs will be forwarded to it and will be the basis of the expense and financial budgets.

When the production program has been completed, it should show the quantities of each product to be manufactured during each month or other time division of the period. In most cases, the planning department will break it down farther to show the quantity of each component part of each product which must be produced. The final pro-

[1] See p. 54.

FACTORY DEMAND

WEEKLY STATEMENT OF ORDERS AND PRODUCTION TO______ 192__

| PRODUCT | TO BE SHIPPED MONTH OF | | | | SALES BUDGET TO____ | 192__ TO BE SHIPPED TO____ | 192__ PRODUCED TO____ | % PROD. TO TOTAL ORDER | MATERIAL PURCHASE AUTHORIZED | AUTHORIZED FACTORY ORDERS | STANDARD STOCK DATE____ | ACTUAL STOCK DATE____ | 192__ TOTAL ORD. ON FACTORY TO____ | 192__ TOTAL ORD. ON FACTORY TO____ | % INC. OR DEC. | 192__ PRODUCED TO____ | TOTAL SHIPPED LAST YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | |

Modification Of A Form
Used By The Perfection Stove Co.

FIG. 24

A WEEKLY COMPARISON OF ACTUAL AND BUDGETED SALES AND PRODUCTION

gram in this form may then be analyzed to show the amount and kind of each raw material which will be required and when it probably will be needed. This information is necessary to enable the engineering and tool departments to make changes in design, bills of material, and blue prints economically, and tool up the various operations; the production manager's organization to work out its detailed plans and schedules and the purchasing department to procure the raw materials and supplies. From time to time during the forecasted period, the sales and production programs must be revised to meet conditions as they actually develop. Fig. 23 shows part of a monthly production program of a large rubber manufacturing plant.

The procedure which has been discussed above could be applied in its entirety only in well-organized concerns, producing standard or semi-standard products in quantities. However, the principle of anticipating and preparing for the sales demand has wide applicability. The extent to which it can be applied naturally decreases as we approach the small concern which is manufacturing a purely custom-built product to the customer's specifications.

**Sources of Authority for the Manufacture of the Product.** The three principal sources of authority are (1) the production program, (2) the sales order, and (3) the manufacturing requisition. All of these sources are not present in every plant.

The production program, previously discussed, and the parts and assembly programs derived from it, may authorize directly the manufacture of the specified quantities of the items indicated on it.

In many concerns, the chief and perhaps only source of authority is an order from the sales department. In others, it may be the authority for the manufacture of special product to the customer's specifications.

Some plants manufacture certain finished parts and supplies to stock. Inventories of these items usually are maintained on a maximum-minimum basis. When the inventory of a given item falls to a certain minimum quantity, the balance of stores department writes a manufacturing requisition for the maximum or ordering quantity. This requisition is the authority of the production organization to manufacture the specified quantity. The maximum and minimum quantities may be determined in part from the requirements of the production program. Fig. 25 shows a manufacturing requisition.

**The Planning Department.** The production program, when finally approved, becomes the responsibility of the planning department. When the authority to manufacture is properly released by the head of the production organization, the planning department must initiate and control the production and assembly of the parts and products

called for in the parts and assembly programs which have been derived from the production program. Similarly, in a concern manufacturing strictly to order, the sales order when finally accepted becomes the responsibility of the planning department in so far as the functions of production are concerned. In the latter case, delivery dates should not be promised without the knowledge and consent of the planning department.

The planning department of the modern plant has been modified considerably from that originally described by Taylor.[1] The personnel function in industry has been developed. As a result, most of

NAME OF PART

REQUEST FOR MANUFACTURING ORDER

*Courtesy—Remington-Rand, Inc.*

FIG. 25
A MANUFACTURING REQUISITION

the personnel duties which were performed by Taylor's planning department have been transferred to a personnel department. The work of determining production standards usually is done by a time-study department which may or may not be connected with the planning department. Many other illustrations could be given. With the differentiation and development of the functions of management, there has been a tendency to relieve the planning department of those functions and duties which do not pertain directly to the planning and control of production.

The duties of the planning department will vary between plants for many reasons, such as differences in product, control methods, or the progressiveness of the managing executives. In those concerns

[1] *Shop Management*, by Frederick W. Taylor, p. 111.

in which the planning department is well developed, it may (1) analyze orders and make delivery promises, (2) plan and route orders, (3) write various production papers, such as material requisitions, production orders and tool and equipment lists, (4) place and follow up tool orders, (5) see that material is available and apportioned for use on planned orders, (6) determine time relationships between the processing of operations and flow of orders through the shop, or the rates of production of various parts and products, (7) dispatch work to the shop or the employee, (8) control the movement of materials and work, (9) control plant capacity, and (10) maintain adequate planning records.

**Centralized and Decentralized Planning.** Methods of planning and controlling production may be classified in two general groups—those in which the work is largely centralized and those in which it is largely decentralized. Inasmuch as many degrees of centralization are possible, there is no sharp dividing line between them.

Under centralized control, all of the work of planning and controlling production is brought into the planning department. It supervises directly the work in the shop, planning and scheduling it in detail. It assigns and issues the work to the operatives, determines the machines on which each job shall be done, controls the movement of materials and work-in-process, and performs similar duties of shop management. Centralization of control is intended to get greater coordination by bringing together all of the work of control at one point. The foreman is relieved of all duties except those which have to do with instruction and leadership in the shop and the removal of shop interferences to production. Undoubtedly the efficiency of the foreman is increased when he is relieved of many of the routine duties which have been imposed on him under the military form of organization. However, under centralized control, he may feel that the management of his department is around him rather than through him; that his position in the organization has been depreciated; that he is expected to get results without having sufficient control of his shop. As a result, there is the danger that the foreman's cooperation may be lost or at least given grudgingly. Without such cooperation, the effective control of production is difficult at best. Furthermore, centralized control is likely to become top heavy and cumbersome in large organizations.

Under decentralized control, the planning and control of production within the department is handled by the department. Such work as the assignment of men to jobs, the routing of work to machines, the scheduling of work within the department, is handled from the shop office. Usually, this work is done by a shop clerk, often called the department planning clerk. In matters of discipline and the routine per-

formance of his work the shop clerk reports to the foreman. In such matters as methods of handling his function, he reports functionally to the planning supervisor. This arrangement has the advantage that it strengthens the authority of the foreman, and as a result gets greater cooperation from him. Usually, it is easier to make use of his valuable experience with the production problems of his shop.

Decentralized control undoubtedly has greater flexibility than centralized control, for the reason that shop conditions and shop planning are brought closer together. The shop foreman and the shop clerk have a more intimate knowledge of the individual characteristics of the men and machines in the shop than can any clerks in a central planning office, unless the plant is of moderate size and has a highly developed system of control and intercommunication. When interferences to production arise in a given department, often they can be handled to better advantage and schedules adjusted with less difficulty by the shop executives. Provided the work moves into and out of the department on time, the schedule is not affected by minor adjustments within the department. Of course, the planning department must be informed of such interferences even though no action may be required of it. Because of its greater flexibility, decentralized planning usually is found in the larger plants. In smaller plants, the planning department is in closer contact with actual shop conditions. Therefore, central planning with its possibilities of greater coordination of control, may be used successfully.

There are cases where central planning has been worked out successfully for plants of considerable size. Before the war, the Franklin Manufacturing Company developed a central planning system. While it functioned effectively, it required the use of highly developed methods and expensive control apparatus.

**Types of Orders.** In the average manufacturing plant, many types of factory orders are used which affect, directly or indirectly, the control of production. In general, such orders may be classified as (1) manufacturing orders, (2) expense orders, and (3) asset orders.

Manufacturing orders control the manufacture of the product. The more common classes of such orders are (1) the manufacturing order, (2) the production order, (3) the production sub-order, (4) the replacement order, (5) the rush order, and (6) the repair order.

The manufacturing order authorizes the manufacture of a given number of units of finished product. It may originate either from a production program, a sales order or a manufacturing requisition. Usually, it is issued directly from the office of the chief production executive. In the case of the organization shown on page 104, this would be the vice-president in charge of production.

The production order authorizes the manufacture of a given quantity of a particular component part. It may be written by the planning supervisor with the approval of the production manager. The determination of the quantity to manufacture is affected by a number of factors such as the stock of parts on hand, the extent to which parts are interchangeable between different styles and models of product, their rate of consumption and others. Fig. 28 is an example of a production order.

The production sub-order is the authorization issued to the department foremen to process a given operation on an order. Fig. 26

[illegible] ORIGINAL

CARTRIDGE DEPARTMENT PRODUCTION SUB-ORDER No.______

_SHOP

______ QUANTITY WANTED______

RATE OF DELIVERY______ QUANTITY STARTED______

ARTICLE______ QUANTITY GOOD______

______ QUANTITY SCRAP______

OPERATION______

USE MACHINES______

ESTIMATED MACHINE HOURS REQUIRED FOR THIS LOT______

REMARKS______

SIGNED

| TICKLER DATES | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| SUB-ORDER WRITTEN | | ISSUED TO SHOP | | RECEIVED IN SHOPS | | RETURNED TO DEP'T OFFICE | | POSTED TO PLAN OF WORK | |
|---|---|---|---|---|---|---|---|---|---|
| DAY | HOUR | DAY | HOUR | DAY | HOUR | DATE | HOUR | DAY | HOUR |
| | | | | | | | | | |
| BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | |
| | | | | | | | | | |

*Courtesy—The Winchester Repeating Arms Co.*

FIG. 26

A PRODUCTION SUB-ORDER—FRONT

shows such an order. It is issued by the planning supervisor. In many plants, the operation ticket [1] or work order performs this function in place of a formal production sub-order. If there is a large quantity to be processed requiring considerable time, the amount of scrap and good work may be recorded daily on the back of the sub-order. In addition to giving the foreman the authority to process, the sub-order may be used to close out the operation after its completion, thereby assisting in the dispatching of the order.

In addition there may be replacement orders authorizing the

[1] See p. 146.

**POSTED BY:—**

| DATE | | DATE | PRODUCTION | | SCRAP | | BALANCE DUE |
|---|---|---|---|---|---|---|---|
| DAY | NIGHT | | LBS. | QUANTITY | LBS. | QUANTITY | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | TOTAL | | | | | |

*Courtesy—The Winchester Repeating Arms Co.*

FIG. 27

A PRODUCTION SUB-ORDER—BACK

processing of a quantity sufficient to replace the amount scrapped on a production order. Such orders are issued only when the amount of scrap has been considerably greater than that anticipated. In most plants, rush orders giving priority to particular production orders are issued occasionally. In many cases, too often. Replacement and rush orders tend to disrupt the normal routine of the shop and should be issued only when absolutely necessary. Repair orders may be issued from time to time authorizing the manufacture of repair parts. Obviously, such orders would be used only in connection with the manufacture of an assembled product.

Expense orders are issued for work in connection with the repair and maintenance of plant and equipment and other work of an expense nature. Asset orders are issued to authorize work which increases the capital value of the plant. The scope of this book does not permit discussion of these two types despite their importance.

As will be seen, the primary purpose of factory orders is to facilitate the control of manufacturing activities through the proper release of authority.

**The Planning and Routing of Orders.** The detailed planning and routing of orders begins when the production manager's office receives some form of authority to process a given quantity of product. This authority may be released by means of a monthly production program or a manufacturing order as previously stated. On the basis of this authority, production orders are written for each component part required. In an assembly industry having order control, the planning department, under the authority of the production order, will plan and schedule the production of each part.

The planning and routing of the order require (1) the determination of the kind and amount of material needed to manufacture the required quantity. This information is obtained originally from the engineering or the production organization; (2) the determination of the operations to be performed. The processing of the product is usually done by the engineering department when there is one. In other cases, the processing may be done by the planning department with the assistance of the production executives. By some means, the list of operations through which each part or product must pass and the class of machine on which each operation should be performed, must be determined; (3) the determination of where each operation shall be performed. The selection of the department in which each operation on a part or product shall be performed depends largely on the relation of the operations to one another and the location and equipment of the different departments. Routing endeavors to obtain the best flow of work through the plant and the best utilization of the

equipment; (4) the time required to process a unit quantity on each operation. Without such information, the order could not be scheduled or checked against available machine capacity with sufficient accuracy; (5) the tools and equipment required for each operation; and (6) the origination of various production papers giving to the scheduling and preparation sections of the planning department and the production organization the information necessary for the proper performance of their respective functions.

99D 1128 6-17

**CARTRIDGE DEPARTMENT PRODUCTION ORDER No.__**

| TO SCHEDULING SECTION | DATE ORDERED | | | DATE WANTED | | | DATE STARTED | | | DATE FINISHED | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MO | DAY | YEAR | MO | DAY | YEAR | MO | DAY | YEAR | MO | DAY | YEAR |
| PLEASE__________THE FOLLOWING | | | | | | | | | | | | |

| Q'T'Y IN THIS LOT | DESCRIPTION |
|---|---|
| | |

REMARKS

QUANTITY STARTED__________ QUANTITY FINISHED__________

TICKLER DATES

| TRACER TICKETS PROVIDED | | ORDER ENTERED | | GENERAL PLAN WRITTEN | | Plan of Materials and Stores Issues Written | | MATERIALS APPORTN'D | | PLAN OF WORK WRITTEN | | Tool Lists and Stores Issues Written | | TOOLS APPORT'ND | | GAGE LISTS WRITTEN | | SUB ORDERS AND SET UP TICKETS WRITTEN | | SENT TO SCHEDULING SECTION | | RECEIVED BY SCHED SEC | | ORDER RETURNED | | COST REC D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DAY | HR. | DAY | HR. | DAY | HR. | DAY | HR | DAY | HR | DAY | HR | DAY | HR | DAY | HR | DAY | HR | DAY | HR. | DAY | HR | DAY | HR | DAY | HR. | HR | DAY |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | | BY WHOM | |

*Courtesy- The Winchester Repeating Arms Co.*

FIG. 28

A PRODUCTION ORDER

The planning and routing of orders in a process or assembly industry having flow control is fundamentally the same as in an assembly industry having order control. Usually there are relatively fewer orders for larger quantities. The routing may be established permanently by the nature of the processes. For these and other reasons, the problem, while fundamentally the same, is usually simpler in process or assembly industries having quantity production and flow control.

**The Planning Records.** If the product is a standard article, the information necessary for planning and routing probably will have been compiled and entered in a permanent record. For convenience, this record may be called a master plan of work. A typical master plan of work contains the following information:

(1) Name and description of the product or component part.
(2) Its product symbol.
(3) The materials.
 (a) Kind
 (b) Quantity required per unit of product.
(4) The operations.
 (a) The operation number.
 (b) A description of the operation.
 (c) The department in which each operation is performed.
 (d) The machine class for the operation.
 (e) The time per unit of product required for each operation.
 (f) The tools and equipment required for each operation, such as jigs, fixtures, gauges, dies, etc.
(5) The number of parts required per unit of finished product.

Fig. 29 is an example of a master plan of work.

Most of the information on the master plan of work is obtained originally from the product and production engineers, some from the time-study department, and some from the production executives.

In the case the product is being manufactured to the customer's specifications, the planning of the order will be based on bills of material submitted by the engineering department or similar papers in the case of a nonengineering industry. The bill of material, in addition to giving a list of parts and their material requirements, should give much of the information found on the master plan of work. It applies specifically to the particular order under consideration, and in many cases, the data is estimated rather than observed or recorded.

**Writing the Production Papers.** On the basis of the information given by the master plan of work or the bill of material, the various production papers are made out. The nature of these production papers, the number of copies of each which are made out, the executives who receive them, and similar considerations depend on the system of production control under consideration. The more common are:

(1) *Operation Tickets.* These tickets are sometimes called work orders or time tickets. They are the authority of the workman for performing a given operation, and in some instances they may take the place of the production sub-order. They are often the basic records from which the workman's pay is determined. On them is recorded the standard time or the actual time when the operation is started and finished, or both. In addition, it gives such other information as may be necessary to identify and control the operation. Usually they are made out in duplicate.[1] Fig. 40 is an example of an operation ticket.

(2) *Material Requisitions.* The material requisition is a written order on the storeroom for the issue of a certain kind and quantity of material. It is the basis of the entries in the stores ledgers covering

[1] See p. 146.

[illegible] 17

# GUN DEPARTMENT GENERAL PLAN

SHTS. NO. ____ ARTICLE ____ MODEL ____

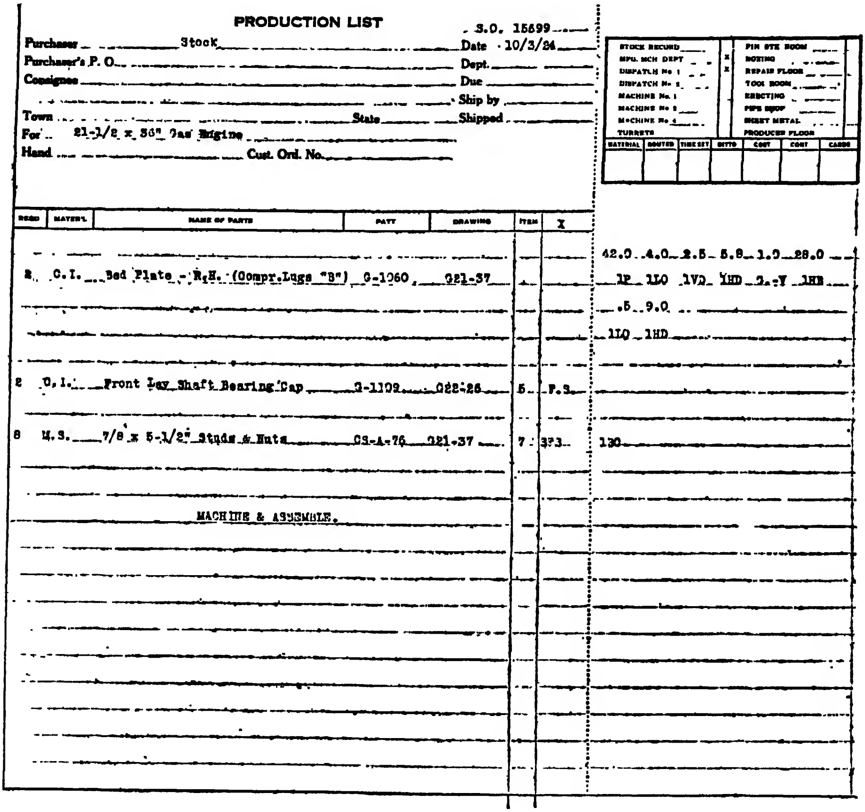
REFERENCE ____ DATE OF ORDER ____ GUN ORDER NO. ____

BASIS ____ MATERIAL ____ CORRECTED TO ____ DATE WANTED ____ QUANTITY ____

| OPER. NO. | DESCRIPTION OF OPERATION AND HOLDING POINTS | MACHINES | | FIXTURES | | TOOLS | | FORMAL TOOLS? | PIECE WORK PRICE PER 100 | MAN HOURS PER 100 | MACH. HOURS PER 100 | MANUFACTURER GAGES | | INSPECTOR GAGES | [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DESCRIPTION | QUANT. | DESCRIPTION | QUANT. | DESCRIPTION | QUANT. | | | | | DESCRIPTION ALLOWANCES AND TOLERANCES | QUANT. | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

the transaction and may be the basis of material costs. In some cases the materials and supplies used directly in the product may be requisitioned by the department foreman rather than the planning department. Fig. 79 shows a material requisition.

(3) *Route Sheets.*—The route sheet is an instrument used in the planning, routing, and dispatching of work. Its use will be explained presently.



PRODUCTION LIST

S.O. 15699

Purchaser Stock — Date 10/3/24
Purchaser's P. O. — Dept.
Consignee — Due
Ship by
Town — State — Shipped
For 21-1/2 x 36" Gas Engine
Hand — Cust. Ord. No.

STOCK RECORD / MFG. MCH DEPT / DISPATCH No 1 / DISPATCH No 2 / MACHINE No. 1 / MACHINE No 2 / MACHINE No 4 / TURRETS
PIN STK ROOM / BORING / REPAIR FLOOR / TOOL ROOM / ERECTING / PIPE SHOP / SHEET METAL / PRODUCER FLOOR

| MATERIAL | ROUTED | TIME SET | DITTO | COST | CONT | CARDS |
|---|---|---|---|---|---|---|
| | | | | | | |

| REQD | MATER'L | NAME OF PARTS | PATT | DRAWING | ITEM | X | |
|---|---|---|---|---|---|---|---|
| | | | | | | | 42.0 4.0 2.5 5.8 1.0 28.0 |
| 2 | C.I. | Bed Plate – R.H. (Compr.Lugs "B") | G-1060 | 021-37 | | | 1P 1LO 1VD 1HD 2-Y 1HB |
| | | | | | | | .5 9.0 |
| | | | | | | | 1LO 1HD |
| 2 | C.I. | Front Lay Shaft Bearing Cap | 3-1109 | 022-26 | 5 | F.S. | |
| 8 | M.S. | 7/8 x 5-1/2" Studs & Nuts | CS-A-76 | 021-37 | 7 | 373 | 130 |
| | | MACHINE & ASSEMBLE. | | | | | |

*Courtesy—The C. & G. Cooper Co.*

FIG. 30

A BILL OF MATERIAL FOR USE IN PLANNING

(4) *Route Tags.*—These are tags which are attached to the work to identify it and to direct its movement through the shop. Fig. 31 is an example of a route tag.

(5) *Production Sub-orders.*—In some plants sub-orders are written, under the authority of the production order, for each operation

which must be performed on an order. Their use will be explained later. Fig. 26 is an example of a sub-order.

(6) *Tool and Equipment Lists.*—These are lists made from the master plan of work or the bill of material, showing the kinds and

**ROUTE TICKET**

DATE________

PART

MODEL

QUANTITY LOT No.

| OPER. No. | OPERATION | QUANT | FIN | MAN |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | | | | |
| 12 | | | | |
| 13 | | | | |
| 14 | | | | |

1912 50M 11-16 ROUTE TICKET

*Courtesy—The Winchester Repeating Arms Co.*

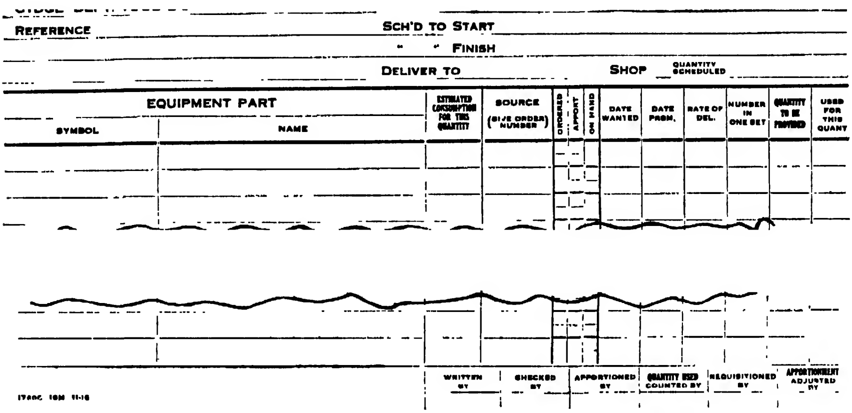
FIG. 31

A Route Ticket

This fits into a metal clip on the tote box

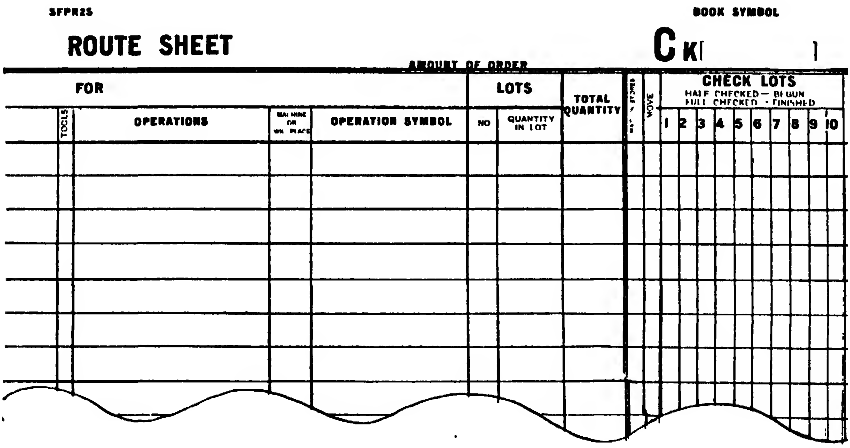
quantities of tools and equipment required for each operation on an order. They enable the preparation section to check the availability of tools and equipment and to insure that they are on hand when needed. Fig. 32 is an example.

The information which appears on the production papers must be obtained by some one, some time during the manufacture of the order. If the information is standardized as far as possible and the work of




*Courtesy—The Winchester Repeating Arms Co.*

FIG. 32
A Tool List




*Courtesy—Mr. John A. Fisher.*

FIG. 33
A Route Sheet

supplying it is organized and done in advance of processing, the shop will get better and more complete information than would otherwise be possible and at less expense.

In a plant in which the preplanning of production has been well

developed, the production papers will be made out in the planning section. They are forwarded by it to the scheduling section, which will schedule the various operations and eventually will dispatch certain of them to the shop.

Forms do not constitute management. They are merely convenient instruments for applying certain principles and performing certain functions of management. Consequently, they should be designed to facilitate the smooth operation of the system, which in turn should be designed to meet the needs of the particular manufacturing problem. The forms shown are merely illustrative. In a great many cases, they could not be used without considerable modification.

**The Route Sheet.** The route sheet is an instrument which is used for checking the planning and dispatching of production orders. Fig. 33 is an example. A separate sheet is made out for each order. The character of the information usually found on the route sheet is indicated below:

(1) Name and description of the part or product.
(2) Part or product symbol.
(3) The drawing number.
(4) Quantity in the lot.
(5) The kind and quantity of material required.
(6) The operation list.
  (a) Sequence of operations.
  (b) The department in which each operation is performed.
(7) Columns for checking the completion of each operation and the movement of work.
(8) Boxes for checking the progress of planning and preparation.

As the various production papers are written, the proper box is checked and initialed. When planning has been completed, the route sheet is forwarded with the other production papers to the scheduling section. The form shown in Fig. 34 is intended to be used for scheduling as well as planning the order.

The route sheet is one of the earliest devices developed for controlling the planning and production of an order. From it have come most of the more complex graphs and control boards sometimes found in order-control systems.

In industries using flow control methods, the route sheet usually is not found. Planning, preparation, and scheduling are performed with a view to maintaining a desired rate of production rather than a desired rate of progress of a specific order or lot.

**Scheduling.** Scheduling has been defined as the function of determining when or at what rate the various operations shall be performed and the events in the manufacture of a product shall occur.

The principal factors which may enter into the making of a schedule

are (1) the time required for procurement by purchase, (2) the time required for procurement by manufacture, (3) the time required for assembling the product, (4) the assembly relationships, (5) the availability of productive capacity, and (6) the relative need for the order. In some instances, raw materials are purchased for a specific order or

**ROUTE SHEET**

Part Name ______________________ Order No. ____

Part No. ____________ ________ Lots, Lot No. ____

Material ______________________ Material Basis ____

Scrap Allow. 5% Quant. Want. 300 Quant. Start. ___ Quant. Fin. ___

| O.T. | M.R. | T | Sched. | Mach. | S.O. | M.T. |
|---|---|---|---|---|---|---|
| E.R. | M.A. | M.A. | H.J. | H.J. | E.R. | E.R. |
| 1/4 | 1/6 | 1/7 | 1/5 | 1/9 | 1/4 | 1/4 |

| Op. No. | Operation. | Dept. No. | Mach. Class | T | M | O | Start | Finish | Good Work | Scrap | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Mill | 21 | MP | | | | 2/10 | 2/10 | 305 | | |
| 2 | Slot | 28 | SH | | | | 2/11 | 2/12 | 312 | 3 | |
| 3 | Drill | 34 | DB | | | | 2/13 | 2/13 | | | 2/13-T |
| 4 | Stores | S | | | | | | 2/14 | | | |
| | | | | | | | | | | | |

FIG. 34
A Route Sheet

it may be necessary to replenish stocks of raw materials and supplies. In the case of an assembled product, there may be certain parts that are purchased. The time required to procure such items must be considered in making a schedule. Similarly, there are often certain supplies or materials which are produced within the plant. In determining time relationships, a principal factor is the time required to put the parts or products through their processes. This time includes the time required to move materials and work-in-process. If the product is an

assembly of many parts, the time required to assemble them must be considered. Furthermore, assembly relationships must be considered. Some parts require more process time than others. Some are assembled with other parts in sub-assemblies before finally being assembled in the finished product. Such factors must be considered before the time when each part or operation should start can be determined. It is difficult to maintain a schedule unless machines or men and work-places of the right kind are available when an operation is scheduled to start. Consequently, some control of productive capacity is necessary, particularly when the progress of a large number of orders must be controlled. Finally, the need for some items is greater than for others. Certain orders may be for stock. Others may be required to meet the emergency demands of a valuable customer. Therefore, it is often necessary to consider the relative need for various items in making or revising a schedule.

In general, the work of scheduling falls into one of two classes—scheduling with order control and scheduling with flow control. In the first instance, each order is scheduled separately with regard to the date when it is wanted in finished stores or the assembly floor, and its progress through the various operations and departments on its operation list is followed. The manufacturing and assembling time relationships between the various parts entering into the finished product often are of great importance. The condition of plant capacity must be watched constantly.

In scheduling with flow control, the conditions of production approach a continuous flow of work through the plant into stores. Sometimes, in a plant manufacturing large quantities of product to stock, a machine or group of machines may work steadily on a certain operation on a part or product for months. Under such conditions, scheduling consists in checking the flow of work from each operation against a predetermined rate of flow. The progress of the order, as such, is not followed, although the flow of production usually is broken up into orders and in turn into lots of convenient manufacturing size to facilitate the work of production and cost control.

The route sheet in Fig. 34 illustrates the principles of scheduling with order control. When it is received, together with the other production papers, the blocks at the top of the sheet, marked SO, OT, MT, and Tools, will have been checked, showing that the sub-orders, operation tickets, move tag, and tool list have been written and should be attached. Inasmuch as the operation tickets and the move tag require no further preliminary attention, the first two blocks will carry the planning clerk's initials and the date when the production papers were written.

The schedule clerk determines the approximate date when each order should start and finish. To do this, he must have data relating to process and assembly times and assembly relationships. Fig. 35 is a conventional assembly diagram of the manufacture and assembly of a product requiring the manufacture of eight parts, two sub-assemblies, and the final assembly. The horizontal lines represent the parts and assemblies. The vertical lines represent the joining of the parts in assemblies and the joining of major parts and the sub-assemblies into the finished product. If the length of the line FA represents the time

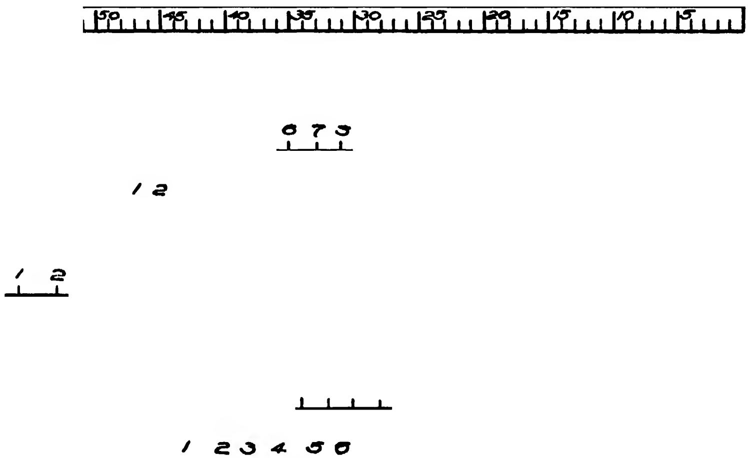


FIG. 35
An Assembly-Sequence Chart

required for the final assembly of a standard lot, the length of the line SA #1, the time required for sub-assembly #1; the length of the line P #4, the time required for the processing and moving of part #4, the starting-point of line P #4 indicates the relative time at which its manufacture should begin in order that it may be completed in time for its assembly with P #2 and P #5. The time scale at the top of the diagram shows that in this case P #4 should start 45 days before the manufacture of the products is completed; SA #1, 29 days; FA, 15 days. The numbers on the part lines are the operation numbers. Their position indicates the relative time when each should begin. If the product were being manufactured to order in standard quantities, such an assembly chart could be used for controlling the progress of orders. The actual

calendar dates, rather than the number of working days before completion of final assembly, would be shown on the scale. If more or less than the standard quantity were manufactured, the time relationships would be modified accordingly. In many cases, parts may be manufactured to stock to be withdrawn from stores subsequently as

PRODUCTION RECORD

Part Name ____________ Start ______ Part No. ______

Remarks ____________ Finish ______ Order No. ______

Quantity ______ Lots ______ Production Rate 550

| | Op. No. 1 Punch | Dept. No. 12 | Mch. Class PP | Op. No. 2 Form | Dept. No. 14 | Mch. Class PF | Op. No. 3 Form | Dept. No. 18 | Mch. Class PF | Op. No. 4 Drill |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Prod. | Scrap | Total Good | Prod. | Scrap | Total Good | Prod. | Scrap | Total Good | Prod. |
| 2/12 | 800 | 25 | | | | | | | | |
| 2/13 | 900 | 50 | | | | | | | | |
| 2/14 | 1300 | 40 | | 600 | 110 | | | | | |
| 2/15 | 1100 | 10 | 5500 | 525 | 80 | 3500 | | | | |
| 2/16 | 1050 | 10 | | 615 | 92 | | | | | |
| 2/17 | 600 | 6 | | 400 | 75 | | | | | |
| Total | 5750 | 141 | 5609 | 2140 | 357 | 1783 | | | | |
| | | | | | | | | | | |
| | | | 11,000 | | | 2000 | | | | |
| | | | | | | | | | | |

FIG. 36
A PRODUCTION RECORD

needed. In the case of a given part, such as P #4, the schedule clerk would then be interested only in the time relationships indicated by the line P #4 and the relation of the amount ordered to the amount on hand, the rate of consumption, and the available machine capacity. Either from an assembly chart or from statistical data the schedule clerk determines the date when each operation should start and finish. These dates would be entered tentatively on the route sheet, and the

sub-orders. They would then be forwarded to the load clerk, who would check the dates against available machine capacity. On each sub-order, the planning section has previously entered from its master plan of work the machine capacity required for each operation to process the quantity specified by the production order.

As previously noted, in many plants the determination of routings, process times, assembly relationships, and other factors is a matter of the experience of the production executives. Stock-chasers are expected to start orders through the shop in the proper sequence and get them through to the assembly floor at the proper time. Such haphazard control can only result in delays, inefficiencies, and increased costs.

In scheduling with flow control, the schedule clerk is interested very little, if at all, in the progress of a specific order through its various operations, but is greatly interested in the maintenance of the required rate of flow of work from each operation. While as before, there must be standards of performance against which actual performance can be checked, the standards and methods are different. Fig. 36 shows a form which might be used for flow control in such cases as the manufacture of standard nuts and bolts in quantities. In the example shown, the production program calls for the manufacture of the part or product in question at the rate of 5,500 pieces per week during the period covered by it. Evidently, the order was scheduled to start on February 12th. In the column headed total good, the figures underlined show the cumulative total which should have been produced to the end of any given week.

**The Control of Capacity.** In the case of order control, it is necessary to have some knowledge and control of the availability of machine capacity. With a large number of orders moving through the shop, many of which require the same kind of capacity for different operations and different lengths of time, such control is most important. Otherwise there is no assurance that capacity of the right kind will be available when an order arrives in a department, unless there is an excess of men and equipment over normal requirements.

The function of the load clerk is to control plant capacity. A number of methods of performing this function have been used. One method is to use a simple statistical record such as that shown in Fig. 37. For each department and each class of machine there is a separate sheet. On each sheet there are vertical columns for the order numbers for which machine capacity has been set aside, the amount of machine capacity which has been apportioned, and the amount which has been released. There is an apportioned and released column for each week. In addition to the machine time required, each sub-order shows the machine class on which the operation should be performed.

On the load sheet, the order and operation numbers are entered. Opposite them, the machine hours required are entered in the apportioned column for the week in which the operation is to be done. At any time, a balance can be struck to show the total apportioned. When a sub-order is closed out after the completion of the operation, the process

MACHINE CAPACITY CONTROL

No. Of Machines 20 Shop D3M

1 Shifts. Hrs. 48 Mch. Class L24E

Total Capacity 960 Avail. Mch. Hrs. 860

Foreman J. Smith

| | Op. | 2/12 | | 2/19 | | 2/26 | | 3/5 | | 3/12 | | 3/19 | | 3/26 | | 4/2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Order No. | No. | A | R | A | R | A | R | A | R | A | R | A | R | A | R | A | R | |
| 2162 | 2 | | | 144 | | | | | | | | | | | | | | |
| 2172 | 12 | | | 96 | | 96 | | 96 | | | | | | | | | | |
| 2175 | 4 | | | | | | | 120 | | 52 | | | | | | | | |
| 2182 | 7 | 300 | | 210 | | 100 | | | | | | | | | | | | |
| 2190 | 13 | 500 | | 400 | | 200 | | | | | | | | | | | | |
| 2162 | 2 | | | | 144 | | | | | | | | | | | | | |
| 2190 | 13 | | | | 400 | 400 | | | | | | | | | | | | |
| | | 800 | | 850 | 544 | 796 | | 216 | | 52 | | | | | | | | |
| | | | | 544 | | | | | | | | | | | | | | |
| | | 800 | | 306 | | 796 | | 216 | | 52 | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |

FIG. 37
A MACHINE CAPACITY CONTROL

is reversed. The sub-order on being received from the shop is routed through the load clerk. The order number is entered as before and the machine hours released are entered in the released column for the week in which the operation was scheduled to be done. At the top of each sheet appears the number of machine hours per week which are available for this class of machine in the particular department. A comparison of the total available machine capacity with the balance

available indicates roughly whether it is safe to schedule an operation for the day shown on the route sheet. In the event that there is danger that there will not be available machine capacity on that date, the schedule clerk should be notified accordingly. If the dates are satisfactory, the load clerk merely initials and dates the machine block on the route sheet and returns it with the sub-order to the schedule clerk.

In some cases, a closer control of capacity may be required, in which case it may be desirable to use some device such as the Gantt layout chart,[1] which shows graphically each job planned for each machine for each hour in each day of the period covered by the chart.

**Preparation in the Planning Office.** The function of preparation must be performed in any organization which attempts the preplanning of production with a view to developing a more effective control of production. When the production orders and sub-orders have been scheduled and checked for the availability of machine capacity, they must be checked for the availability of materials and tools. Otherwise orders may be held up by shortages of these items. In order that this may be done, the material requisitions, tool list, and route sheet for each production order are forwarded to the preparation clerk. Upon receipt of these papers, the preparation clerk sees that the material called for on the material requisitions is set aside for the order on the stores books. If previous production requirements have been so great that there is not sufficient material available for apportionment against the order, a new supply must be purchased. The preparation clerk is notified of the fact, and when the new supply will be on hand. If the shortage of material interferes with the schedule, the schedule clerk must be notified by the preparation clerk. Similarly, the preparation clerk sees that tools and supplies which are needed for the order and which are carried regularly in stores are set aside for it. Usually the preparation clerk places orders with the tool department for any special tools and equipment which may be needed. He secures promise dates for the completion of tool orders in conformity with the schedule shown on the route sheet and notes these dates on the tool list. The progress of tool orders is followed to insure that they will be delivered as promised. When materials for the requisitions have been apportioned and promise dates have been received for tool orders, the material and tool blocks on the route sheet are initialled and dated by the preparation clerk. The route sheet and material requisitions are then returned to the schedule clerk.

In the case of a system of flow control, the availability of tools and materials might be checked on duplicate copies of tool lists and

[1] See *The Gantt Chart*, by Wallace Clark.

material lists, which would then be forwarded to the schedule clerk. Fig. 38 is an example of a material list.

There are many ways in which the preparation function can be performed. The above methods have been given because they are adapted to the forms which have been shown and are relatively simple. They merely illustrate the principle that in so far as such a thing is possible, interferences to production should be anticipated and removed in advance of actual production.

REFERENCE ________ DATE OF ORDER ________ ORDER No ________

________ DATE WANTED ________ QUANTITY ________

| PART | | DESCRIPTION OF MATERIAL | DIMENSIONS OF MATERIALS | QUANTITY | SOURCE | CHECK | | | DATE WANTED | DATE PROMISED | RATE OF DELIVERY PER WEEK | DATE RECEIVED | DELIVER TO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SYMBOL | NAME | | | | | SCHED. | ON HAND | APPRL. | | | | | |

COPIES TO

| WRITTEN BY | CHECKED BY | SCHEDULED BY | ORDERED BY | APPORTIONED BY | REQUISITIONS WRITTEN BY |
|---|---|---|---|---|---|

[redacted] 1904C 1900 8 17

*Courtesy—Winchester Repeating Arms Co.*

FIG. 38
A MATERIAL LIST

**Dispatching and the Control of Operations.** In order to control production properly the system should have a control of operations through the proper release of authority for their performance. Otherwise, a foreman may start the orders in his shop to meet his convenience or the degree of pressure exerted by different stock-chasers rather than the needs of the schedule. Orders rarely progress uniformly as scheduled. Some tend to draw ahead of their schedules. Others tend to fall behind. In order to determine the extent to which this is taking

place, the system should make possible a check of actual production against scheduled production. Furthermore, it should have a positive means of closing out orders to enable the production and accounting records to be closed out promptly.

The system of filing production papers should be such that they will come automatically to the attention of the dispatch clerk at the proper time. In the case of order control, the production papers and route sheets would be filed in sequence of order numbers. The route sheets would be filed together in some form of loose leaf binder. The sub-order, operation ticket, and material requisition for a given operation are clipped together. The production papers for a given order are filed in sequence of operations in back of the production order. The route tag and the production papers for the first two operations are filed in a tickler file a day or two in advance of the date when the first operation is scheduled to start. In the case of the route sheet shown in Fig. 34, probably they would be filed to come out on February 8th. On that date the route tag, material requisition, sub-order, and operation ticket for operation No. 1 would be sent to department No. 21. The sub-order and operation ticket for operation No. 2 would be sent to department No. 28. At the same time, check marks would be made in the operation column of the route sheet for operations Nos. 1 and 2, showing that the production papers for these operations had been dispatched.

The control device should show the availability of tools. When the production papers for an operation are dispatched, this point should be checked. If the tools are not on the job, steps should be taken to find out why they are not and when they will be. Using the records and instruments which have been described previously, this place of the preparation function might be performed as follows. When the tools for a given operation have been made, the tool department notifies the preparation clerk by a duplicate copy of the tool order or other means. The preparation clerk checks off the operation on his tool list and notifies the schedule clerk, who makes a line check in the tool column of the route sheet, opposite the proper operation. At any time a glance at the route sheet will show the availability of tools for each operation. In the example shown in Fig. 34, the tool orders for all operations have been placed and delivery promises received. The tools have been delivered for all operations except No. 3.

Material or work-in-process should not be moved from one operation or department to another except on proper written authority. The instrument which gives this authority is the move order, signed by some authorized executive. An example is shown in Fig. 48. In complete central planning, the move orders would be made out in the

central planning office. In decentralized control, the move orders usually are made out by the department foreman or inspector. When the material has been moved from stores to the first operation, the material requisition, properly receipted, is forwarded to the planning office, where the schedule clerk checks the movement of material on the route sheet by making a full check in the move column opposite the first operation. The requisition is then forwarded to the balance-of-stores clerk for entry in the stores books. Subsequently, when the job is moved from one operation to the next, a copy of the move order is sent to the planning office, where the schedule clerk checks the movement of the job on the route sheet as before. The route sheet in Fig.

NOTICE OF START OR FINISH OF LOT

Caliber.......................... Lot..........................

Machines.......................... Operation..
Lot Starting )
Lot Finishing) Date.............. Prod.............

Floorman.......................... Date.

Tool Clerk.......................... Date..........................
Floorman Rec.)
First Box ).......................... Date..........................
Last Box ) 2168 5M 7-17

*Courtesy—Winchester Repeating Arms Co.*

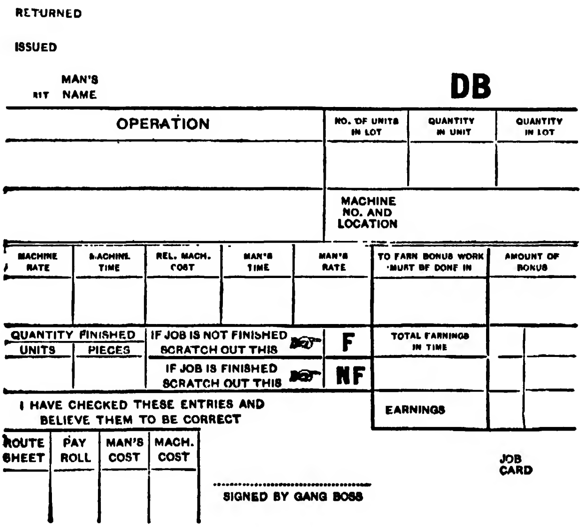
FIG. 39

A NOTICE OF START AND FINISH OF OPERATIONS

34 shows that the job has been moved to department No. 34 for operation No. 3.

In order control, it is usually necessary for the planning office to receive prompt notice of the start and finish of each operation. There are various methods of notifying the office. When an operation starts, a notice such as that shown in Fig. 39 may be made out by the shop office and forwarded to the planning department. On its receipt, the schedule clerk half-checks the operation column on the route sheet opposite the operation. When the operation has been finished, the shop office enters on the sub-order any shop information relating to the operation that is required by it. The sub-order is then forwarded to the planning department. On its receipt, the dispatcher removes from the file the production papers for the next operation to be dispatched and forwards them to the shop, at the same time checking the operation on the route sheet. With the system which has been described, the production papers for operation No. 3 would be sent to

department No. 34 when the sub-order for operation No. 1 was received from department No. 21. The sub-order is then turned over to the schedule clerk, who completes the check in the operation check column for operation No. 1. It is forwarded by the schedule clerk to the load clerk, who enters on the machine-load record the amount of capacity released. As previously stated, the operation ticket may also be used to perform the functions of the sub-order, particularly when the operations are of short duration. When this is done, the operation ticket is provided with check blocks marked F and NF, which can be checked


RETURNED

ISSUED

RIT MAN'S NAME

DB

OPERATION | NO. OF UNITS IN LOT | QUANTITY IN UNIT | QUANTITY IN LOT

MACHINE NO. AND LOCATION

MACHINE RATE | MACHINE TIME | REL. MACH. COST | MAN'S TIME | MAN'S RATE | TO EARN BONUS WORK MUST BE DONE IN | AMOUNT OF BONUS

QUANTITY FINISHED: UNITS | PIECES

IF JOB IS NOT FINISHED SCRATCH OUT THIS F

IF JOB IS FINISHED SCRATCH OUT THIS NF

TOTAL EARNINGS IN TIME

EARNINGS

I HAVE CHECKED THESE ENTRIES AND BELIEVE THEM TO BE CORRECT

ROUTE SHEET | PAY ROLL | MAN'S COST | MACH. COST

SIGNED BY GANG BOSS

JOB CARD

*Courtesy—Mr. John A. Fisher.*

FIG. 40

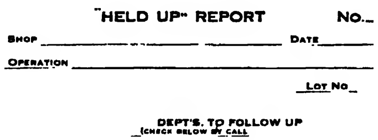
An Operation Ticket Designed for Use with a Hook-Type Planning Board

to show whether the operation is finished or not finished. Fig. 40 shows an operation ticket of this kind.

It is inevitable that from time to time some work will be spoiled. In some cases the work can be reprocessed and saved. In others, it must be scrapped. In starting an order, the number of pieces wanted may be increased by the normal percentage of scrap. Some record of the amount of good work and scrap usually is necessary for the control of quality and may be necessary for payroll purposes. In most cases, the information is obtained from inspection reports, originated daily by each inspector for the work completed in his department. A copy may be forwarded to the planning department for its information. On the route sheet in Fig. 34 this information has been entered in the columns headed "Good Work" and "Scrap" for each operation

The record shows that three pieces were scrapped on operation No. 2, department No. 28.

It is also inevitable that from time to time there will be interruptions to production, even though there may be good control. These interruptions may be minor and of such nature that they can be removed easily by the department foreman without serious effects on the schedule. They may be major interruptions requiring the assistance of the planning or maintenance department. In such cases, it may be necessary for the planning department to change the schedule for an order or reroute it. Therefore, the planning department should receive prompt and complete notice of all major interruptions to production. Fig. 41 shows an interruption report. When it is received from the shop, the schedule clerk notes the interference on the route


"HELD UP" REPORT NO.__

SHOP __________ DATE ________

OPERATION ____________________

LOT NO.__

DEPT'S. TO FOLLOW UP
(CHECK BELOW BY CALL

FIG. 41
AN INTERRUPTION REPORT

sheet in the column headed remarks, opposite the operation which is held up. The report is turned over immediately to the preparation clerk, who is responsible for the prompt removal of the interference. In emergencies, this procedure may be short-circuited by telephone, but an interruption report must be made out by the shop office in confirmation of the telephone notice. The route sheet in Fig. 34 shows that operation No. 2, department No. 28, has been completed and the work moved to department No. 34. However, operation No. 3 has been held up because the tool department has failed to deliver the tools as promised.

**The Order of Work.** In decentralized control, what is known as the order of work may be used to get a closer control of operations. Fig. 42 is an example. Theoretically, such a form is not necessary. Actually it may be, because orders seldom go through exactly in accordance

with schedules. Customers may request a change in delivery dates. Machine breakdowns may delay the progress of the order. For these and other reasons, it may be necessary to give certain orders priority and to hold others back.

The order of work shown in Fig. 42 would be used somewhat as follows. An operation list such as that shown in Fig. 43 would be made out and filed in a tickler file to come out on the day preceding that on which the next operation is to start. On any given day, the operation lists for all orders having operations scheduled to start the

WORK TO BE STARTED IN D3M DEPT. ON 2/13

| Part and Order No. | Oper. No. | Oper. Name | Mach. No. or Class | Reasons Not Started | Will Start |
|---|---|---|---|---|---|
| P21 - 1260 | 8 | Mill Base | M2P | | |
| H20 - 1132 | 3 | Mill Adj. Block | M3H | No Tools | 2/14 A.M. |
| | | | | | |
| | | | | | |

AP 51

ORDER OF WORK

*Courtesy— Remington-Rand, Inc.*

FIG. 42
AN ORDER OF WORK

next day are automatically brought to the attention of the dispatch clerk. The operation lists are sorted by departments and the operations scheduled to start the next day are noted on the order of work for each department as shown in Fig. 42. The order of work may be made out in duplicate. The operation lists are returned to the tickler file against the scheduled date for the following operation. In the afternoon, the order of work for each department is forwarded to it. The following morning, the foreman checks the operations that can be started, notes in the column headed remarks why the others cannot, and sends the original copy to the planning department. In the illustration it will be seen that operation No. 8 on order No. 1,260 can be started, but operation No. 3 on order No. 1,132 cannot, because of

lack of tools. The foreman sends the duplicate copy to the planning office at the end of the day. Some operation which was reported as started may have been held up. Some operation which was held up may have been started. Those operations which have not started are

| No OF PIECES | DATE | ORDER NO. |
|---|---|---|

MANUFACTURING ORDER

AP 119R 30M 3-27 DITTO

*Courtesy—Remington-Rand, Inc.*

FIG. 43
AN OPERATION LIST

entered by the dispatch clerk at the top of the order of work for the next day. They continue to appear on the order of work until the order is out of the department. The order of work is turned over to the schedule clerk, who half checks on the route sheet those operations

which have started. Any interferences also may be noted on the proper route sheet. The order of work then goes to the preparation clerk, who is responsible for removing the interferences. The department cannot start operations which do not appear on the order of work.

If the schedule or routing is changed, the operation list and route sheet must be changed accordingly. Schedule changes on the operation list automatically speed up or retard the order. In some cases rush orders may also be used for emergency or delayed orders, in conjunction with the order of work.

**Progress Reports.** Reports concerning the progress of orders should be made periodically to the planning supervisor, the shop superintendent, and the production manager, in order that they may be apprised of any critical situations which have arisen. Applying the exception principle, only those orders which are behind schedule should be reported, together with the reasons for delays and any action that has been taken. The time of executives should not be wasted in looking over reports of orders whose condition requires no action.

Progress reports should be rendered weekly at least. In many cases, daily reports may be necessary. If the order of work is used, the final copy for Friday, which would be available Saturday morning, should be analyzed. All orders which were not started Friday as scheduled should be checked on the route sheet to determine how many days each is behind schedule. This information is noted on some form of progress report similar to that shown in Fig. 44. In the case illustrated, the need for order No. 1,132 evidently is urgent because the tool makers working on the tools for operation No. 3 have been authorized to work overtime in order to get them out at the earliest possible moment.

**The Flow Control of Operations.** In most cases when flow control is used, large quantities of standard products are being manufactured to stock at some predetermined rate. The manufacture of any given item continues over a considerable period of time. The rate at which it is to be manufactured is determined from the production program. Usually, the availability of productive capacity is determined approximately at the time the program is made. Consequently, a detailed record of available capacity may not be necessary and usually is not found. In place of the route sheet, some statistical or graphical record of progress which will show the actual rate of production compared with the scheduled rate is used. A statistical record of this kind was shown in Fig. 36. Inasmuch as operations continue over a considerable period, operation tickets probably will be and material requisitions may be written in the shop office as required. Sub-orders should be written authorizing the processing of each operation on a lot. On

the back of the sub-order, the production and scrap record for the lot may be entered daily as shown in Fig. 27. As before, there must be some mechanism for placing and following tool production and for removing interferences to production. It will be seen that in most cases the methods for a flow control of production are simpler than those for an order control.

Reports of production and scrap, such as shown in Fig. 45, are received from each shop department daily. If a production record

**PROGRESS REPORT**

Dept. D3M  Foreman J Smith  Date 2/16

| Ord. No. | Op. No. | Part No. | Part Name | Behind Sched. | Cause | Action Taken |
|---|---|---|---|---|---|---|
| 1132 | 3 | H28 | Adjusting block | 3 | No tools | Tool dept working overtime |
| 1129 | 5 | P29 | Slide | 2 | No material | Purch. Dept. notified |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

FIG. 44
A PROGRESS REPORT

such as that shown in Fig. 36 is used, the production and scrap for each order and each operation would be entered daily on the sheets for each product. In the case illustrated, the schedule for the item calls for the production of 5,500 pieces per week. Out of a total of 5,750 pieces produced on operation No. 1 during the first week, 141 were scrapped, 5,609 good. The scheduled production was exceeded by 109 pieces. The first week's schedule for operation No. 2 called for 3,500 pieces; 2,140 were produced, of which 357 were scrapped, leaving 1,783 good. Due to excessive scrap, production was 1,717 pieces less than the scheduled quantity. As in order control, periodic progress reports should be made to the production executives. These reports

1830 2M 7-18

## PRODUCTION REPORT

SHEETS No. ______

SHOP ______ OPERATION ______ DATE ______ 191

| CALIBER | LOT No. | DAY | NIGHT | TOTAL | NEXT OPERATION |
|---|---|---|---|---|---|
| | | | | | |

______
SIGNATURE

*Courtesy—Winchester Repeating Arms Co.*

FIG. 45A
A PRODUCTION REPORT

1831 20M 8-16

## SCRAP REPORT

SHOP........................OPERATION........................DAT

| CALIBER | LOT No. | MACHINE SCRAP | INSPECTED SCRAP | TOTAL SCRAP | TO BE RE-RUN |
|---|---|---|---|---|---|

SIGNATURE

*Courtesy—Remington-Rand, Inc.*

FIG. 45B
A SCRAP REPORT

should show the amount by which the actual cumulative total produced to any given date is less than the scheduled cumulative total, for each operation behind schedule on each order. Such a progress report is shown in Fig. 46. Shortages are also expressed in terms of days required to make them up.

**Closing Out Orders.** There must be some means of notifying all interested parties of the completion of an order. When the last operation sub-order has been received, the production order is removed from

PROGRESS REPORT

Department 21 Foreman J. Smith Date 3/12

| Part No. | Part Name | Order No. | Lot No. | Op. No. | Cum. Total Act. | Cum. Total Sched | Short | Days Lost | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 31 | Rack | 1301 | 8 | 2 | 1783 | 3500 | 1717 | 2 | Def. Tools. – Corrected |
| 34 | Head | 1327 | 10 | 5 | 2540 | 4100 | 1560 | 3 | Held up by prev. Op. Dept 17 |
| " | " | " | " | 8 | 2100 | 3200 | 1100 | 2½ | Held up by prev. Op. |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

FIG. 46
A PROGRESS REPORT

the file and the progress record closed out. Any information of permanent value not shown on the progress record may be indorsed on the back of the production order. These papers are then turned over to the planning section for permanent filing. The planning section may analyze them to correct or modify its planning records or they may be used in planning orders for which no standard planning data are available.

In most cases, the cost department must receive notice of the completion of orders so that it may close out the cost records. A copy of the production order or the assembly order often is used for this

purpose. In some instances, the final operation ticket may perform this function.

**Progress Charts and Production Control Boards.** Various charts and control boards have been developed for controlling production. The production-control methods must necessarily be developed to permit these devices to function effectively. Accordingly, they will differ from the methods described above, although the same fundamental principles are applied. For the most part, these devices are developments of modifications of the assembly chart, route sheet, or the production record which have been shown.

# CHAPTER XI

## PRODUCTION CONTROL IN THE SHOP

WHEN centralized production control is used, all of the work of planning and scheduling production is done in the planning office. The workmen receive their job assignments and the movemen their move orders directly from it. The foreman retains the functions of leadership, instruction, and removing interferences. These are considered by many to be his real functions.

When decentralized production control is used, the planning office plans, schedules, and dispatches to the department rather than the machine or the workman. Operation tickets and move orders are issued from the shop office. The shop clerk, under the direction of the foreman, plans and schedules the production of the shop subject to the schedule dates appearing on sub-orders. Usually, the executive status of the foreman is higher under decentralized than it is under centralized planning. For a number of reasons, some of which have been discussed previously, the present trend seems to be toward decentralized control. Therefore, this type of control will be the basis of the following discussion.

**Planning and Scheduling in the Shop with Order Control.** The production papers received from the planning office should be filed systematically rather than in a convenient drawer in the foreman's desk. If the order of work is not used, probably they will be filed in the chronological order of schedule dates. An exception would be made in the case of those jobs which require considerable time and which must be started quite some time in advance of the scheduled completion date. As the work progresses, the papers would be withdrawn from the file in the chronological order in which they are filed. The sub-orders would be filed by order numbers in an active file. The manner in which the other papers would be handled would depend on the system of shop control in use. If the order of work were used, the production papers would be filed by order numbers. They would be withdrawn in the sequence indicated by the order of work.

A great many devices have been developed for planning and controlling the work in the shop. A discussion of all of them is beyond the scope of this book. Whatever the device, it should show at least

(1) the load of work ahead of each machine or work-place, (2) the specific jobs to be done at each machine or work-place, and (3) the order in which these jobs should be done. One of the earliest devices is the planning board. An example is shown in Fig. 47. There are three sets of hooks for each machine or work-place. The top set holds the operation ticket for the job at present on the machine, the middle set holds the operation tickets for the next job to be done, and the bottom set holds the operation tickets for other jobs planned for the machine in the order of their schedule dates. At the beginning of the day, the shop clerk withdraws from the file production papers for sufficient jobs to keep the shop running throughout the day. Under the

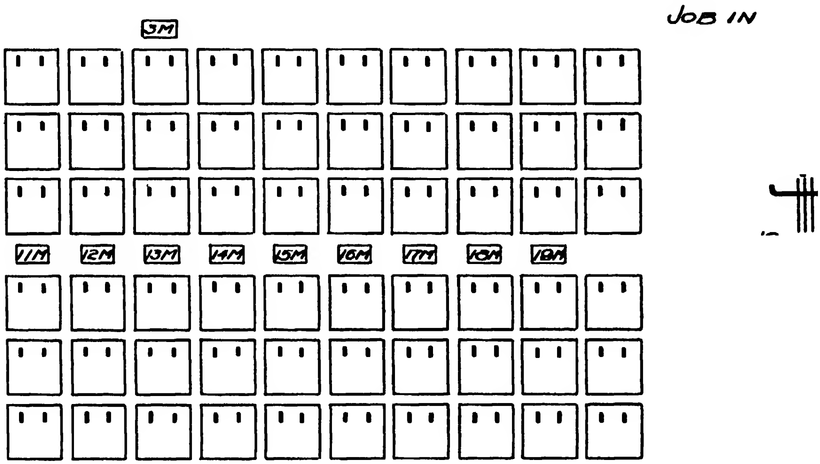



FIG. 47
THE HOOK-TYPE PLANNING BOARD

supervision of the foreman, the jobs are planned for specific machines. The operation tickets for the jobs assigned to a given machine are then arranged on the lowest set of hooks for that machine in the order of their schedule dates. If the order of work is used, it may cause a modification of this arrangement or a rearrangement of the operation tickets for jobs previously planned. The advantage of preplanning production in the shop is that the foreman in a relatively short time can survey the production situation in his shop as a whole and lay out the work for the machines or work-places in a manner that will meet the schedules of the planning office to the best advantage. Unless unusual situations arise in the shop, the foreman is then free to devote most of his time to removing interferences to production in his shop and raising the efficiency of his men. In many shops, the foreman spends

a good share of his time in deciding what job a certain workman shall do next and in seeing that he gets started on it properly.

In the case of the first operation on an order, the shop clerk may give the material requisition and the route tag to the preparation overseer, who sends it to the storeroom with a trucker. The storeroom takes the requisition, attaches the route tag to the material, and releases it to the trucker, who moves it to the department and to the machine, under the direction of the preparation overseer. In some instances the requisition may go directly to the storeroom. The material is then delivered by the internal transportation system at the proper time.

**Dispatching.** In the shop, the function of dispatching is to release to the workman, at the proper time, the authority to perform a certain operation on a specified quantity of raw or worked material required for an order. One of the functions of the planning board is to control this release. Such control obviously has an important relation to the problem of processing orders in the proper sequence at the proper time.

When the workman finishes a job, he brings his operation ticket to the shop-office window. In some cases the method of controlling shop time, wage payment, or cost accounting may require that the elapsed time for the job be recorded on it. If such is the case, the operation ticket will be time-stamped to show the exact time at which the ticket was returned to the shop office. When the work was planned, the shop clerk noted on the operation ticket the employee's name and number, the quantity of work, and the number of the machine on which the work was to be done. When the operation ticket is received from the employee and time-stamped, the shop clerk turns to the planning board and removes the duplicate copy of the operation ticket from the top set of hooks for the machine. The operation tickets for the next job to start on that machine are removed from the middle row of hooks. The original copy is time-stamped to show the time when the operation started and is given to the workman. He withdraws from the shop tool cage whatever tools he may need and returns to his machine. The work has been moved to his machine previously by a shop trucker on the authority of a move order written by the preparation overseer. The shop clerk hangs the duplicate copy of the operation ticket on the top row of hooks for the machine. The operation tickets for the next job in chronological sequence of schedule dates are removed from the bottom set of hooks and hung on the middle set.

**The Preparation Function in the Shop.** The recognition and proper performance of the preparation function is a prerequisite for the smooth running of the shop. The failure to note the absence of work

or certain tools for an order before the workman appears for his operation ticket results in confusion and delay, making it difficult to meet the schedule date for the operation. In the organization which has been set up for illustrative purposes, the preparation function in the shop would be administered by the preparation overseer, under the supervision of the foreman. The manner in which the function is administered will vary between organizations, depending on the production-control methods in use.

When work is received from another department, the foreman or, if there is one, the preparation overseer receipts the move order. The quantity received is noted on the operation tickets for the next operation on the order and on the operation sub-order if one is used. It is then forwarded to the planning office, where the movement of the order is checked off on the route sheet.

The preparation overseer should watch the third row of hooks on the planning board. If the top pair of operation tickets on the third set of hooks for a given machine has a check-mark across the face of it, the materials and tools for that operation are available. If the preparation overseer sees a pair of tickets that have not been checked, he immediately investigates the condition of the order. If the material and tools have been received, he puts his check-mark on the operation tickets. Otherwise he takes such action as may be necessary to remove the impending interference. The shop clerk does not move tickets from the third to the second set of hooks unless the preparation overseer's mark appears on them.

In some cases, tool coupons may be used. They would be made out by the planning department and would be received in the shop office with the other production papers. When the preparation overseer wishes to check the availability of tools for a given operation, he takes the tool coupon to the tool cage and determines whether any special tools listed on it have been received from the tool department. If they are on hand, the coupon is given to the tool-cage clerk, who gets the tools listed on it and places them in a tote box. The coupon is then returned to the shop office. When the workman gets his operation ticket, he is given the tool coupon for the operation. He hands it in at the tool-cage window and receives the tote box containing his tools. When the operation is finished, the workman returns the tote box and tools to the tool cage. The tool coupon is given back to him and destroyed. When some such procedure is used, the tool coupon is an instrument aiding the performance of the preparation function and the control of shop tools.

Interferences to production should be reported promptly to the planning office by the shop office. When a machine is closed down, a

colored ticket, indicating the nature of the interference, may be hung on the planning board on the top set of hooks for the machine.

**The Inspection Function in the Shop.** The standards of quality are equally as important as the standards of quantity. With some types of work they may be much more important. Consequently, the control methods should afford (1) some effective method of comparing the actual quality produced with the standard of quality. Otherwise, defective work may pass through a number of subsequent operations after it has been spoiled. Obviously, the labor that has been expended on such operations has been wasted. If the product is assembled, defective parts reaching the assembly floor increase the labor and

**TRANSFER TICKET.**

Part and Order No.................................... Date....................................

Part Name..............................................................................

Last Operation..........................................................................

From ....................................Dept. To. ....................................Dept.

Quan. Del.................................... Quan. Rec'd. ....................................

Clerk ....................................Clerk....................................

Inspector....................................Inspector....................................

(TRIPLICATE)

Form A. P. 959

*Courtesy Remington-Rand, Inc.*

FIG. 48
A Move Ticket

expense of assembly and may materially impair the quality of the finished product; (2) they should afford some method of recording results from the standpoint of quality. Many plants have highly organized inspection departments, responsible for the maintenance of quality standards. If it is to function effectively, the inspection organization must receive prompt, detailed reports showing where the quality standards are not being maintained properly and why; (3) in those plants in which it is desirable to pay the employee in proportion to the quality as well as the quantity produced, they should afford some method of noting quality results on the original record of the employee's earnings. As in the case of the other functions of management, there are many ways in which these fundamentals can be applied. The following method is fairly typical.

When the employee completes an operation on an order, he checks and initials the operation on the route tag and sets the work to one

side. He takes his operation ticket to the shop office and receives the operation ticket for his next job as previously described. One of the functions of the foreman and the preparation overseer is to see that finished work is moved promptly. When any considerable quantity of finished work accumulates at a machine, the foreman or the preparation overseer writes a move order such as are shown in Fig. 48, authorizing the shop truckers to move the work to the next operation or the inspector. The move order usually shows the part name and number, the

INSPECTION REPORT

Department ____________ Foreman ____________ Date ____________

| Part No. | Op. No. | Order No. | Lot No. | Empl. No. | Quant. Good | Quant. Scrap | Total | Remarks |
|---|---|---|---|---|---|---|---|---|
| P27 | 15 | 1283 | 10 | 1162 | 560 | 40 | 600 | Undersize |
| P11 | 2 | 1071 | 6 | 1157 | 523 | 92 | 615 | Defective material |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

FIG. 49
AN INSPECTION REPORT

operation name and number, the employee's number, the order and lot numbers, and the quantity started. This information is obtained from the route tag.

When the work comes to the inspector, it is inspected for quality and quantity. The inspector notes the quantity of good work completed on the route tag. The quantity of good work and scrap is noted on the inspection report and on the back of the move order. Fig. 49 is an example of an inspection report. The move order is sent to the shop office, where the amount of good work and scrap is noted on the operation sub-order. This information may also be noted on the

employee's operation ticket, depending on the system of wage payment in use. Finally, the inspector makes out a move order authorizing the movement of the work to the next operation. If the work is to be moved out of the department, a move order distinctly different from the department move order may be used. Often such move orders are made in duplicate, so that one copy can be returned as a receipt.

**Closing out Orders in the Shop.** When an order is completed, the shop files and records should be cleared of all production papers relating to it. The planning office should be given complete information concerning the operation which affects its control of production.

When the original operation ticket is turned in at the shop-office window by the workman and is time-stamped, the duplicate or board copy of the ticket is removed from the planning board. The sub-order is removed from the active file and clipped to the operation tickets.. When the move order is received from the inspector, the information relating to good work and scrap is indorsed on both copies of the operation ticket and in some cases may also be indorsed on the back of the sub-order. The production papers are then forwarded to the planning office.

In the planning office, the information on the sub-order and the duplicate operation ticket is used to check the route sheet and the machine-capacity record. The original copy of the operation ticket goes through to the cost department. In some cases the time taken on the operation first may be extended in the planning office or the time study section and the employee's efficiency computed.

**Flow Control in the Shop.** When large quantities of standard products are being manufactured continuously for stock or for the assembly floor, the work is flowing constantly to and from the machines in a more or less steady stream. Specialization and the division of labor often are highly developed. A man may work on a job consisting of a single operation on a piece for weeks or months. Certain machines regularly work on certain operations. Accordingly, the planning and scheduling of work may be a minor function in the shop.

For convenience, the flow of any particular kind of work may be broken up into orders, which in turn may be broken up into lots. The operation sub-orders for each lot may be the only production papers sent by the planning office to the shop. When a lot of work arrives in a department, it may not be necessary to determine on what machine it shall be processed and in what sequence in relation to other lots. Therefore there may be little or no necessity for a shop planning board of the kind previously shown. Operation tickets usually are written in the shop office for each day's production for each employee.

As the work arrives in the department, the preparation overseer

sees that it is moved by the truckers to the proper machine. His familiarity with the operations being performed regularly in the department makes it unnecessary for him to consult some device such as the shop planning board. His chief concern is to see that at all times there is an adequate bank of work ahead of each machine. In addition, he must see that work is removed promptly as completed. When highly productive automatic or semi-automatic machinery is being used, this function may be very important. If it is not performed properly, the work piles up around the machine and in the aisles, hampering the operator and impeding the movement of work through the shop. When any quantity of work accumulates at the machine, a move order is written by the foreman, the preparation overseer, or in some cases the machine adjuster.

When the work has been inspected, the inspector indorses the quantity of good work and scrap and the causes on the back of the move order or makes some record such as a weight slip. At the close of the day, the inspection information on the backs of the move orders or weight slips is summarized on an inspection report such as that in Fig. 49. The original copy is sent to the chief inspector and the duplicate copy to the shop clerk.

The shop clerk enters the quantity of good work and scrap on the employee's operation ticket and on the back of the sub-order as shown in Fig. 27. The operation ticket and the duplicate copy of the inspection report are forwarded to the planning office. The sub-order for a given operation and lot is not sent to the planning office until the operation is closed out as far as that particular lot is concerned.

The methods of moving work into and out of a department fundamentally are no different from those in the case of order control.

# CHAPTER XII

## QUALITY CONTROL

**The Importance of Quality Control.** The quality of the product is that combination of attributes which distinguishes it from similar products. Quality control is the function of insuring that these attributes conform to certain prescribed standards, and that their relationships to one another are properly maintained. A standard may be any

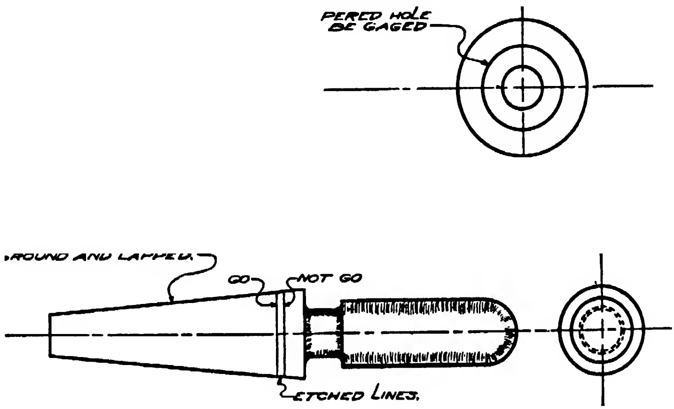



FIG. 50
A TAPERED PLUG GAGE

generally accepted criterion. In the case of a manufactured product, the standards for the various attributes must be such that the product will satisfactorily meet the customer's demands. Inspection is the function of determining for a given item or items the extent to which these attributes conform to the prescribed standards. In the manufacture of interchangeable metal parts, uniformity of size and contour, conforming to specifications, is vitally important. Consequently, in such manufacture inspection includes gauging, "a process of measuring manufactured materials to assure the specified uniformity of size and contour." [1] A gauge is "a device for determining whether or not one or more of the dimensions of a manufactured part are within specified limits." [2] Fig. 50 illustrates a tapered plug gauge and its use.

[1] *Tolerances, Allowances, and Gages for Metal Fits,* by the American Engineering Standards Committee, December, 1925.

[2] *Laws of Manufacturing Management,* by L. P. Alford.

Mr. L. P. Alford states as a principle of manufacturing that "the quality of manufactured goods is a variable with an upward trend under conditions of competitive manufacture." [2] While this statement may be subject to some modification, it is sufficiently correct for a large number of industries. One form of competition is quality competition. Once the public becomes accustomed to a higher standard of quality it will not return readily to a lower standard. Unless properly controlled, higher quality may result in higher costs. Therefore, in the majority of modern industries it is most important that the standards of quality be maintained and advanced when necessary to meet the public's increasing quality demands, but with the greatest economy. Consequently, quality control is an important phase of modern management.

Properly organized and centralized quality control has a number of advantages. It results in greater uniformity of product and more dependable quality, a distinct advantage in distribution. It is not necessary that a manufacturer produce the highest quality to be successful. However, it is most desirable that the degree of quality produced be maintained invariably, in so far as economical manufacturing permits, in order that the public in purchasing units of the particular kind or brand, may have confidence that it will always receive this degree. The scrap problem is brought under control. By varying the strictness of inspection, the percentage of loss can be controlled for economical production, within the limits set by the standards of quality. By pointing out the causes of scrap, the inspection organization can be a powerful influence for its reduction. With such reduction, there are fewer interferences to production due to the scrapping, replacing, or reworking of materials. Consequently, the ease and accuracy with which production is controlled is increased. The costs of production are reduced. In the case of an assembled product, good quality control results in greater interchangeability of parts. Inasmuch as parts require little or no fitting, assembly costs are reduced. Furthermore, strict interchangeability makes it possible to give the customer better service in promptly supplying repair parts that will replace worn or broken parts without requiring considerable fitting. For these and other reasons, a good control of quality usually is essential to successful manufacturing. Radford states as a fundamental principle of manufacturing that "the positive and continuous control of quality to definite standards within limits and at all stages of manufacture is at the root of production economy." [1]

The maintenance of the highest standards of quality, consistent with economical manufacturing and the class of goods being produced,

[1] *The Control of Quality in Manufacturing*, by G. S. Radford.

does not necessarily mean a reduction in the per capita production of the plant. In fact, many industrial executives feel that if quality is properly controlled, quantity will follow as a natural consequence. Wisely selected standards are educational. They compel the organization to use the best available methods and guide it in their use. Increased production follows naturally. It must be recognized that quality control, like other phases of management, can be refined beyond the point of diminishing returns. Obviously, unnecessary inspection and standards of quality that are unjustifiably high are to be avoided. The point of diminishing returns depends on the nature of the manufacturing problem. Its determination is largely a matter of judgment and experience.

The development of effective quality control can be accomplished only as the result of a careful analysis of the product and its attendant production problems from the standpoint of quality maintenance. Such analysis should begin with the design of the product and the procurement of materials and should bring within its scrutiny every phase of production until the product is finally shipped. It does not follow that the authority of the inspection organization shall extend over every phase of production, except in so far as the maintenance of quality is concerned.

The development of a good inspection organization is a requisite for successful quality control. Quality is an intangible thing in many respects. It is difficult to measure and control. Furthermore, it is not exact and invariable. Standards of quality can be set up, but exact, continuous attainment of these standards is impossible. Furthermore, the close attainment of standards when carried beyond a certain point will result in prohibitive costs. Deviations from the standards of quality must be permitted in the interests of economy. However, such deviations must be controlled. Otherwise, they will tend to become larger and larger, resulting in a variable quality that is unsatisfactory to the public. A trend in this direction is natural. The quality of the raw materials varies. Due to the wear of tools and other reasons, the processes themselves will vary. The greater the permissible deviations from the quality standards, the greater the ease with which the production organization can attain the desired production. To prevent such deviations from exceeding permissible limits, there must be an organization, charged with the responsibility of maintaining reasonable standards of quality, which will watch vigilantly all deviations from such standards and take such action as may be necessary to prevent their growth. Such an organization is usually known as the inspection department.

**The Basis of Quality Control.** There are five factors in the control of quality—(1) the selection of the attributes in which each unit of product must agree, within the practical limits of economical manufacturing; (2) the selection of quality standards; (3) the development of methods and instruments for determining and controlling the degree of quality produced; (4) a procedure for checking the accuracy of the instruments; and (5) an organization for quality control.

As previously stated, the attributes and their standards must be selected with a view to meeting satisfactorily the quality demands of the public. Their selection requires a meeting of the minds of a number of executives whose manufacturing interests, to some extent, are not exactly in accord. The sales executive, closely in touch with the consuming public, is best able to advise regarding changing quality demands. It may be necessary to discount his advice partially, inasmuch as the sales organization naturally desires maximum quality and minimum prices to facilitate distribution, an ideal which may be impracticable if profits are to be maintained. The engineering executive is able to advise regarding the attributes necessary for the successful functioning of the product. He also may have a tendency to insist on unnecessarily high quality standards due to a natural desire for mechanical perfection. The production executive is interested in quality standards because of their relation to quantity production and costs. He desires standards of quality that will not increase the difficulty of maintaining high production and low costs. His tendency may be to insist on standards of quality that are too low. The inspection executive is able to advise regarding the practicability of maintaining suggested quality standards and their relation to economical standards of production. The materials executive is able to advise regarding the relation of materials to quality maintenance. To harmonize these views, some committee, such as the product committee discussed in Chapter V, may be desirable.

The final selection may include a number of attributes of dimension, finish, color, strength, and others. Attributes must be selected for the product not only in its final form, but also for each stage in its production. Consequently, consideration must be given to the nature of the manufacturing processes involved.

Standards are a basis of comparison. They may be the result of custom or convenience or may be developed from some fundamental law. In the Bureau of Standards at Washington there are standards of volume, weight, length and others which have been made as accurately as is humanly possible. Our measures in daily use have been compared, directly or indirectly, with these standards. In the industrial organization there must be certain standards for each of the various

attributes of the product with which it can be compared at each stage of its production, to determine the extent to which the desired attributes are present. It should be possible to express these standards in units which are universal, at least in so far as the particular industry is concerned, and which are easily read and understood by the average employee.

If the control of quality is to be effective, there must be some practical means of comparison. Such means will vary with every industry, in some cases crude and in others highly refined. Furthermore, it must be possible to apply these means economically. In the manufacture of interchangeable metal parts, gauges have been developed which permit a direct, quick comparison. Examples were shown in Plate 14.

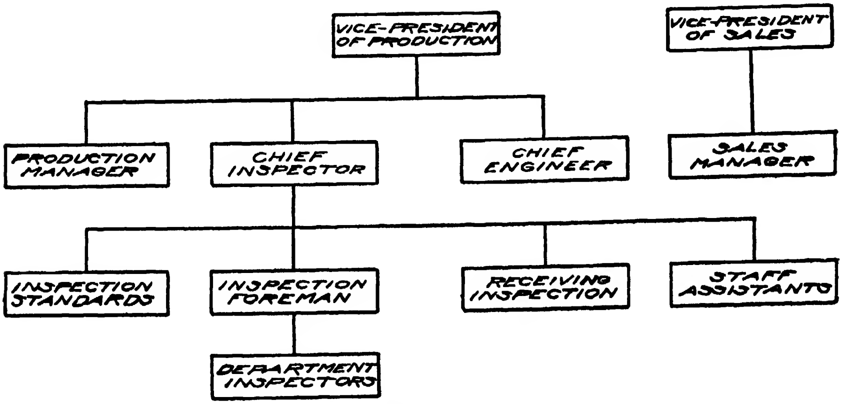


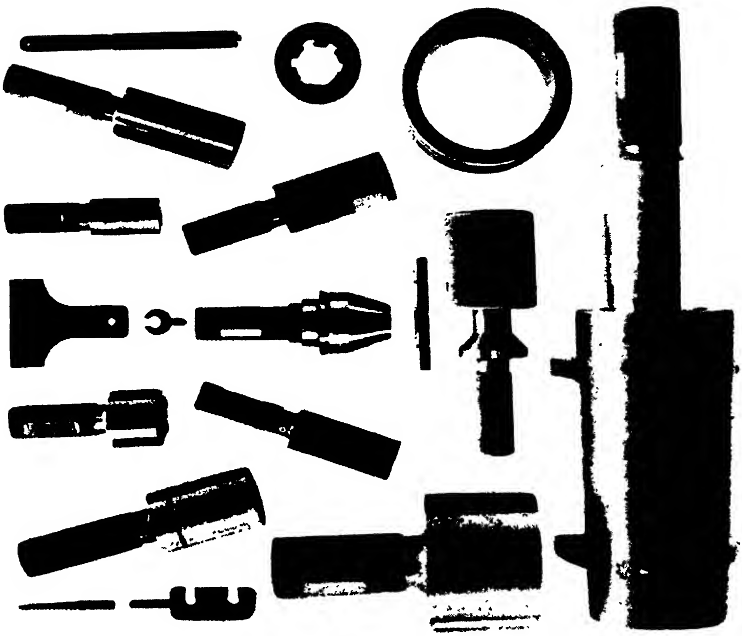

FIG. 51
THE INSPECTION ORGANIZATION

Whatever the instrument for determining the degree in which a particular attribute is present, it is desirable that it be such that the average employee can use it with little training. It should be accurate and sensitive to degrees greater than those required of the product.

The instruments themselves may become inaccurate, due to wear, improper use, or other reasons. Consequently, it is desirable to have some central point under the authority of the inspection department, where these instruments may be checked for accuracy. This may be a standards section under the inspection department. This section is equipped with highly accurate master standards and means of comparison.

Finally, the effectiveness with which quality is controlled is affected by the efficiency of the inspection organization.

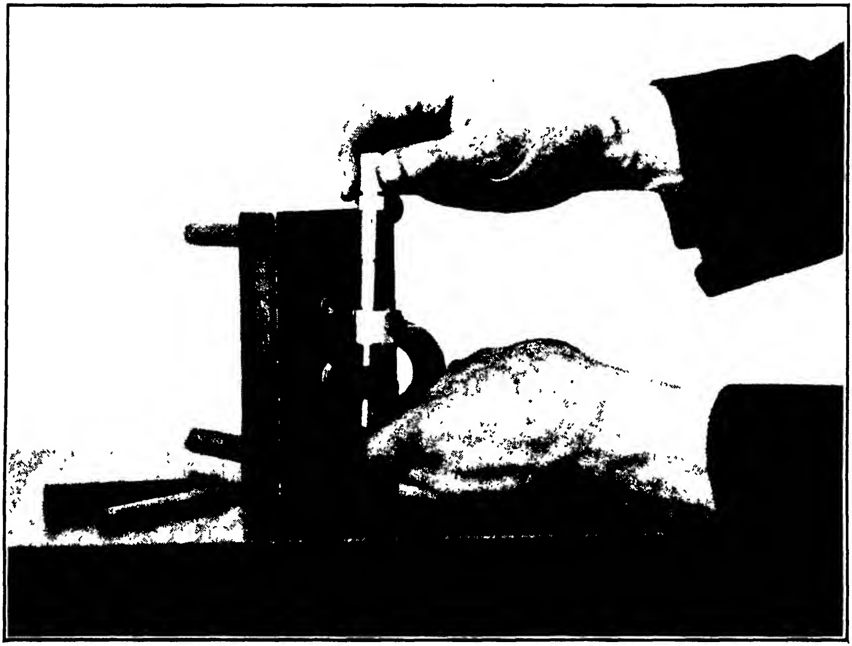
**The Organization for Quality Control.** An inspection department organization is shown in Fig. 51.



*Courtesy—Brown and S*

PLATE 14

EXAMPLES OF GAGES



*Courtesy—Brown and Sharpe Mfg. Co.*

PLATE 15

GAGING JIG BUSHINGS

In the above organization the chief inspector reports directly to the vice-president in charge of production. In some plants he reports to the chief engineer. Occasionally he reports to the production manager. However, it is probably better to give the chief inspector a rank equal to that of the major sales, production, and engineering executives, for the reason that these executives have a natural tendency to be biased somewhat in their views regarding quality control. If he is inferior to them in rank, he may be forced to give their views more than their proper weight. The responsibility for controlling quality economically should be fixed solely on the chief inspector, subject, perhaps, to the general supervision of the product committee. He should have the necessary authority to perform his function efficiently. Mr. L. P. Alford states as a principle of management that "the inspection function in manufacturing for highest efficiency must be independent of, but coordinate with, the functions of engineering, production, and sales." [1] In order to discharge his responsibilities properly, the chief inspector should have mechanical sense and considerable tact and personality to enable him to discover and remove the causes of excessive deviations from the standards of quality.

Reporting to the chief inspector, there is an inspection foreman who directly supervises the work of the department inspectors. He must see that the quality standards are applied correctly and continuously. In large organizations there may be a foreman in charge of the inspectors in each major shop division. These foremen report directly to an assistant chief inspector.

The department inspectors are engaged in inspecting and sorting the worked materials that have been processed in their respective departments. Work that is nonstandard must be separated from that which is standard. Instructions must be written to show what disposition shall be made of the nonstandard work. Some idea of the duties of the department inspector has already been given in Chapter XI.

The supervisor of inspection standards has charge of the inspection-standards section. He is responsible for the accuracy of all instruments of comparison. These instruments should be checked periodically against master standards. In order that this may be done properly, the supervisor of inspection standards should have a well-equipped standards laboratory containing precision measuring devices. He should be a highly skilled mechanic with considerable experience in the making of tools and gauges. Under him there may be a number of skilled mechanics engaged in checking the accuracy of tools, jigs, fixtures, and gauges.

The foreman of receiving inspection is responsible for the quality

[1] *The Laws of Manufacturing Management*, by L. P. Alford.

of all raw materials and supplies received into the plant. Such materials and supplies must be checked to insure that they conform to the specifications in the purchase order.

The chief inspector may also have one or more staff assistants reporting to him. They handle special problems in quality control and such other duties as may be assigned to them. They may analyze reports from the department inspectors, similar to Fig. 49, making such investigations as may be necessary to determine the causes of unusual deviations from the quality standards. Under the direction of the chief inspector they may work with the engineering and production organizations in developing methods that will decrease scrap without decreasing production on operations that have been causing trouble. Working with the personnel organization, they may endeavor to develop better methods of wage payment and promotion that will decrease turnover among the inspectors and increase their efficiency.

**The Responsibility for Quality.** The kind and character of the various attributes of the product are determined by the manner in which the production organization does its work. The skill and care with which it makes the product determine the quality. Therefore the production organization is primarily responsible for the quality of the product. The inspection organization is responsible for a thorough, accurate comparison of the product with the standards of quality, and for analysis of the causes of deviations from such standards which will lead to their removal.

The inspection department should be responsible for stopping losses which may result from failure to meet the quality standards. If a piece is machined improperly, all subsequent work done on it is lost. Subject to such general supervision as may be exercised, the inspectors should be the final authorities in determining what work is standard and what is not. Furthermore, the inspection organization should be the final authority in the determination of what and how much inspection should be given to the product after each operation. If poor work is due to defective tools or poor adjustment, it will continue to be produced until the cause is removed. In such cases, the authority of the inspectors should include the right to close down the machines producing the scrap until the condition is corrected.

**Factors Affecting the Work of Inspection.** The degree of quality required, the nature of the processes, the amount and kind of inspecting necessary, are interacting factors affecting the work of inspection. In some cases the higher the degree of quality required, the greater the care and precision that must be exercised in inspecting the work. Each inspector inspects a smaller quantity of work. Consequently, the inspection organization must be larger. More skilled and consequently

higher priced inspectors may be required. In other cases, scientific developments resulting in improved and simplified instruments for quality control make it possible to increase greatly the quality of the product without increasing the cost of inspection. Not many years ago, the hardness of metal after heat treatment was determined by means of a file. Today, a more accurate determination of this attribute can be obtained with no more effort, by means of such instruments as the sceleroscope and the Brinnell testing machine.

The character of the product affects the amount of inspection required. Some products are rough and crude, requiring little inspection for the work-in-process or the finished product. Other products may require highly exact processing. Obviously, the latter case will require much more inspection than the former. A machine, composed of a number of parts, may be required to produce certain results with a high degree of accuracy. Those parts which affect the functioning of the machine must be machined, in whole or in part, to certain exact dimensions within specified limits of deviation. The final assembly must be inspected to insure that it will produce the required results.

The nature of the operations performed on a given component part affects the amount and kind of inspection that are required. Some operations may require only casual inspection for finish. It may not be necessary to inspect every component produced on such operations. Sampling methods may be satisfactory. If subsequent operations depend on the accuracy with which a given operation is performed and the proper functioning of other components of the mechanism depends on a highly accurate machining of the finished component, it may be necessary to inspect each component produced on the particular operation, using highly accurate and sensitive instruments of comparison. Furthermore, operations differ in respect to the ease with which the quality of their output may be controlled. In some cases, the permissible deviations from the exact dimensions of the component may be very small. A little wear in the tools, gauges, or the devices for holding the work may result in a large increase in the amount of nonstandard work. These holding devices may be complicated, making it difficult to keep them free from chips or other foreign elements. This, in turn, may make it difficult to seat the component in the device properly for correct machining.

As noted previously, the authority of the inspection organization is a factor in the work of inspection. The inspection force is responsible for the maintenance of quality standards. It must have the necessary authority to enforce these standards.

**The Major Types of Inspection.** To control the quality of the product properly, inspection must be extended to all fields of productive activity

which directly or indirectly affect the quality of the product. The major types of inspection are (1) material inspection, (2) tool and equipment inspection, (3) process inspection, and (4) product inspection. Two major factors, men and machines, have not been included. Undoubtedly there is a function of personnel inspection. However, it is usually performed by the personnel department and the production executives in the normal course of their activities. The inspection of machines with a view to anticipating interferences to production due to breakdowns is one of the principal functions of the maintenance department. Similarly, the inspection of drawings and tracings is an important function of the engineering department.

Some idea of the nature of these fields has been given. The quality of the product is affected by the quality of the materials that go into that product. Therefore their quality must be controlled by specifications, reinforced by inspection of all materials received into the plant. This inspection can be given best by a crew of trained inspectors under the supervision of the chief inspector. If the tools and the holding devices, known as jigs and fixtures in the metal-working industries, are inaccurate, obviously the work produced by them will be inaccurate also. Therefore, they should be inspected by the inspection standards section before they are released to the shop. Similarly, if the gauges are inaccurate, they may pass work which is inaccurate and which may cause trouble later in processing or assembling. Gauges also should be checked by the standards section. The necessity for product and process inspection has been discussed previously in sufficient detail.

**Methods of Inspection.** There are two general methods of inspection —central inspection and floor inspection. With central inspection, all or part of the work of inspection is centralized at one point. This does not mean that there is only one central inspection point for the shop or even for a department, although in most cases there is but one central inspection point in a given department. However, there may be more than one, located for convenience in serving the machines and operatives. Central inspection has certain advantages. It clearly separates inspection from production, facilitating the control of work When carried to its ultimate conclusion, all worked material in the department, not in process, is stored in the central inspection crib. When the employee finishes a batch of work it is delivered to the crib. The next batch of work for the employee, as indicated on his operation ticket, is issued to him, if it has passed inspection. Under such conditions, there is more assurance that the work will be processed in the proper order and in the proper condition. All work passes through the central crib after each operation, insuring that it will receive such

inspection as may be necessary before being moved to the next operation. All batches not actually in process are stored in the crib, making possible a clean open shop, facilitating the performance of operations and the movement of work through the department. If the work is conveyed in standard, self-counting tote boxes, the number of boxes stored in the crib gives an approximate idea of the load of work ahead of the department. In most cases, the method of central inspection is not developed to this extent, for a number of reasons. Unless properly worked out, it may mean greatly increased movement of work in the department. This increased movement may offset the advantages of completely centralized inspection when there is a continuous, quantity production of standard items of very low unit value, when the quality requirements are such that inspection after each operation is not necessary, when sampling inspection is sufficiently thorough, and when the size or weight of the item is great. In many cases, rearrangement of the equipment in the shop is necessary before central inspection can be introduced economically. However, central inspection may make possible economies sufficient to justify such rearrangement. In addition to those indicated above, it may be possible to employ less skilled and expensive inspectors without impairing the quality of inspection, inasmuch as the work of inspection is centralized and can be placed under the immediate supervision of a highly skilled and experienced inspection foreman. Furthermore, the work of inventorying work-in-process, in plants which follow the practice of annual or semiannual inventories, is reduced and its accuracy increased.

Floor inspection has to do with the inspection of the work at the machine. It may be used to supplement central inspection in the case of work that cannot be brought economically into the central inspection crib. It may involve the close, accurate inspection of each piece produced on a given operation or it may involve only a casual sampling of the work. Inasmuch as the floor inspectors work independently to a large extent and have greater personal responsibility, they may be paid more highly than the crib inspectors, depending on the nature of their work.

**Sampling.** The method of sampling depends on the law of averages. It assumes that a relatively few pieces selected at random from a box of work will represent the box with sufficient accuracy. When standard work is being produced in quantity it may be satisfactory, particularly when each piece has a low unit value and the operation does not need to be performed with a high degree of accuracy. In order to reinforce the results of sampling, the first and last pieces of a lot usually are inspected carefully. The foreman or a floor inspector may patrol the machines constantly, gauging the work from the ma-

chines at random, watching particular operations which may be more difficult to control than others. In some instances, work may not be inspected after each operation. When trouble develops, it is necessary to send a pilot piece through the operations subsequent to the last inspection, gauging the piece after each operation, until the source of the trouble is located.

**Deviations from Quality Standards.** Three kinds of standards usually are recognized—theoretical, engineering, and manufacturing standards. The theoretical standard is an ideal. It represents the ultimate development of the product. It is the ideal for which the engineering department is striving. It may be unwise to attempt to approximate it at the moment because the present development of production methods may not permit its economical approximation. Competition may not permit its approximation because as yet the public has not been educated to demand such a highly developed product. Yet it may have some practical value in so far as it serves as a guide to the engineering department in its development of the product. The engineering standard is the exact standard that will give the best performance in the present stage of the products development. In the case of the size and shape of a given part, this standard is represented by the exact dimensions for the part that appear on the engineering drawing. The manufacturing standard is a standard that can be attained continuously and economically in production. It is the engineering standard modified by the permissible deviations from it. It is not possible to attain the engineering standard exactly. In the case of highly accurate interchangeable metal parts, the permitted deviations from the engineering standards of dimension may be as small as ±0.00025″, in some instances. The size of the deviations depends on the nature of the work.

In the manufacture of interchangeable metal parts, a terminology for indicating the extent and size of deviations from the engineering standards of dimension has been developed. The allowance is "the minimum clearance space which is intended between mating parts. It represents the condition of the tightest permissible fit or the largest internal member mated with the smallest external member."[1] In Fig. 52, the allowance for the mating parts, 1 and 2, is 0.001″. The tolerance is "the amount of variation permitted in the size of a part."[1] As shown, the tolerances for parts 1 and 2 are the same, 0.001″. The limits are "the extreme permissible dimensions of a part."[2] In Fig. 52, the limits of the diameter of the shaft are 1.250″ and 1.249″.

[1] *Tolerances, Allowances, and Gages for Metal Fits*, by the American Engineering Standards Committee.

[2] *Ibid.*

In the manufacture of interchangeable metal parts, three classes of gauges are used in controlling the deviations from engineering standards. They are (1) master gauges, (2) inspection gauges, and (3) working gauges. The master gauge is "one whose gauging dimensions represent as exactly as possible the physical dimensions of the component. It is the gauge to which all other gauges and all dimensions of manufactured material are finally checked or compared."[1] The inspection gauges are those gauges used by the inspectors in determining whether the work is within the permissible limits of deviation. The working gauges are those gauges used by the foremen, machine

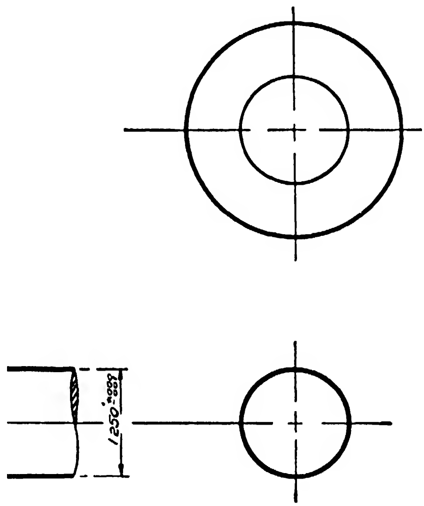


FIG. 52
TOLERANCES FOR MATING PARTS

adjusters, and in some cases the workmen, to check the work as it is produced. Inspection and working gauges will become inaccurate, after a certain amount of use, due to wear. When large quantities of work are being worked within close limits, the gauges may become inaccurate in a relatively short time. They may be taken, periodically, to the inspection standards section for checking. In addition, a few good and bad pieces may be checked against the master gauges occasionally. This may also give some check on the accuracy of the inspectors.

**Inspection Reports.** A standard of quality is maintained at the price of constant vigilance on the part of the inspection organization. A necessary tool in watching the quality produced is a good system of

[1] *Tolerances, Allowances, and Gages for Metal Fits*, by the American Engineering Standards Committee.

inspection reports. An example of an inspection report is shown in Fig. 49. The form, kind, and handling of inspection reports depends on the nature of the quality problem. They are affected by the classification of worked material, which in turn is affected by the nature of the problem. Worked material may be classified as good work which is within the limits of deviation; seconds which are saleable but not as first-grade products and probably not under the company's brand name; shop repairs which are worked materials which can be reprocessed and brought to standard by the employee who originally produced them; and salvage materials. Salvage materials may be classified by the salvage department as salvage repairs, material which can be reclaimed for its original or other uses, and scrap, material which must be sold as junk. The above classification is not universal, but fairly common.

**The Extent of Inspection.** The extent of inspection also varies between concerns with the nature of the quality problem. Mr. G. S. Radford states that "in the S. K. F. Ball Bearing Company's plant at Hartford, where every operation is 100-per-cent inspection, 27 per cent of all the productive workers are employed in the inspection department." [1] He also states that "the most extensive and complex use of inspection is desirable when:

1. The product demands frequent and thorough inspection, as when great accuracy is required.
2. When models are changed with frequency, as in a swiftly advancing art.
3. When labor is unskilled or rapidly changing.
4. When quality standards are being raised.
5. When considerable judgment must be used because standards are being shifted or have not been reduced to a definitely measurable basis." [2]

[1] *The Control of Quality in Manufacturing*, p. 142.
[2] *Ibid.*, p. 173.

# CHAPTER XIII

## TIME AND MOTION STUDY

**The Nature of Production Standards and Time Study.** Standardization has been defined as the codification of the best current practice. Production standardization refers to the codification of the best current practice as related to the performance of processes. It implies not only the standardization of the best method of performing a given operation, but also the standardization of the conditions surrounding the operation which affect its performance.

Time study has been defined as "a searching, scientific analysis of methods and equipment used or planned in doing a piece of work, the development in minute detail of the best manner of doing it, and the accurate determination of the time required." [1] The term operation refers to "any course or series of acts, performed either by one workman or a group of workmen as a unit, which either adds one step to the complete process or constitutes in itself a complete process." [2]

**The Development of Time Study.** Time study was originated by Frederick W. Taylor at the Midvale Steel Company, in 1881. In his book, *Shop Management*,[3] Dr. Taylor says that while foreman of the machine shop, it occurred to him that "it was simpler to time with a stop watch each of the elements of the various kinds of work done in the place, and then find the quickest time in which each job could be done by summing up the total times of its components parts, than it was to search through the time records of former jobs and guess at the proper time and price." From the beginnings made by Dr. Taylor, the technique of production standardization by scientific analysis of the elements in a process has been developed by Sanford E. Thompson, Dwight Merrick, the Gilbreths, and many others, who directly or indirectly have come under Taylor's influence.

Dr. Taylor placed great weight on time study as a factor in the development of better management methods. In his opinion time study for rate setting is the means to attain the fundamental objectives of management, high wages, and low labor costs.[4] Furthermore, he believed that "the art of studying unit times is quite as important

[1] *Management's Handbook*, p. 799.
[2] *Time Study and Job Analysis*, by W. O. Lichtner, p. 155.
[3] *Shop Management*, p. 148.
[4] *Shop Management*, p. 46.

and as difficult as that of the draftsman. It should be undertaken seriously and looked upon as a profession."[1]

The lack of knowledge of the employer, foreman, and workman regarding the proper methods which should be employed in a process, and the proper time which is required for performing it, are other factors which directed Taylor's attention to the necessity for developing more scientific methods for determining these methods and times, and which led to the development of time study. He realized the unreliability of past production records, including, as they must, considerable waste time which has no direct relation to the workman's efforts. He knew from experience and observation that rates set by the guess of a foreman were decidedly unreliable, and often led to rate-cutting. He knew that production standards which the men at first felt were unattainable, were easily met after training in the proper methods.

**The Effect of Standards Development on the Organization.** It was Taylor's experience, verified by others who have followed him, that the standardization of conditions of work, the improvement of equipment and methods, cause increased efficiency in the whole organization. Very often remarkable increases in production are made before any wage incentives are offered. While such work brings large returns, it requires large expenditures, often for a considerable time before these returns become apparent. It may be necessary to study, change, and standardize, at considerable expense, such items as gear ratios, belts and belt tensions, lighting and ventilation, material-handling equipment, and a multitude of other details which affect the processing of work. During the period when this expense is being incurred without corresponding returns, the rank and file of the organization may become openly skeptical. The management becomes discouraged. The board of directors insists that immediate results be forthcoming. It is the period during which plans for the development of modern management methods, which ultimately would bring large returns, are either abandoned or the preliminary work of standardization is seriously curtailed. Such curtailment is most unfortunate inasmuch as this preliminary standardization establishes a firm foundation on which the subsequent time-study work rests. If the conditions surrounding the job vary, the production that can be obtained on a given job will tend to vary as a result. The extent of the variation depends in large measure on the manner and extent of the variations in these conditions.

When results begin to flow from the preliminary work of standardization, there is some danger that the organization will swing from one extreme to the other. Some increase in production is being

[1] *Ibid.*, p. 149.

obtained without much extra effort on the part of the employee, and as a result there is little or no opposition from the working force. Probably the development of standards and better methods has been proceeding in other phases of management. With these developments comes a reduction in the number of annoying interruptions to the normal routine of management, which in itself tends to improve the personnel situation. The organization begins to see the possibilities in the development of production standards and modern management methods. The reaction from the previous attitude may be such that the management, in its enthusiasm, may wish to have the work proceed rapidly and may authorize the expenditure of large sums to speed up the work. Because the development is being unduly forced, the money does not bring the returns that were anticipated. There is danger that grave mistakes in policy, method, or installation may be made. The development work becomes a revolution rather than an evolution. Because of the unsatisfactory conditions which follow, there again is danger that the development work will be abandoned. Only when production standards are developed thoroughly in a manner which approaches a natural evolution, can we hope to get the best permanent results.

**The Effect of Production Standards on the Worker.** After the conditions surrounding the job and the operation method have been standardized, the effectiveness of production standards depends on the attitude of the worker, his ability and training, the incentive to meet the production standards, fatigue, the quality and quantity of the work, the attitude of the management and other factors. If the attitude of the worker is one of suspicion rather than of interested cooperation, the effect of production standards may be to make him sullen and disgruntled. If the development work is properly handled, this effect should only be temporary. To a large extent it may be the reflection of the attitude of the foreman and the minor executives immediately above him. If they have not been entirely sold on the desirability of developing production standards and better management methods, they are apt to be skeptical and even antagonistic. It is only natural that the worker should reflect the attitude of his superior. Furthermore, the worker's attitude is intimately related to the question of training and natural ability. The new method which has been developed for a particular operation may be quite different from the old method. It is probable that the standard of production is considerably higher. To master the new method and attain the standard of production, the worker must establish new thought habits, which involves unaccustomed concentration and mental effort that is seldom welcomed by the average shop employee. With proper training, it is usually

possible for the average employee to master the new method within a relatively short time. Without such training, it may be difficult, requiring a much longer time, and in some instances it may be almost impossible. Obviously, the standard of quality will affect the ease with which he masters the new method, and therefore is a factor which will affect his attitude. The attitude of the worker is important because without his interested cooperation it is difficult to operate and maintain a system of production standards. Furthermore, when we have gained this interest, a great many of the suggestions for the improvement of the operation will come from the workman.

The incentive to attain the production standard is important. Under ordinary shop conditions and modern methods of wage payment in proportion to production, the worker usually is paid a premium which represents a substantial increase over ordinary day wages. Once a few workers in a shop begin to earn premium wages regularly, the attitude of the other workers probably will change quickly to one of interested cooperation. There are many instances where the workers have requested that their jobs be time-studied and placed on a premium basis.

Fatigue is a factor which affects both the success of the production standards and the attitude of the worker. The production standard should not be so high that the fatigue poisons of one day's work are not eliminated from the worker's system before the next, resulting in cumulative fatigue. The workman is justified in protesting against such standards which must result in injury to his health. The reduction of industrial fatigue and the determination of proper fatigue allowances for use in setting production standards is a big problem in itself.

Some people still labor under the misapprehension that production standards, with wage incentives, get greater production from the worker by speeding him up. Production standards do not imply the expenditure of greater energy on the part of the worker, but a more effective expenditure. Where standards are properly set, the danger that the worker's health will be impaired as a result of speeding up is not considerable. The increased production comes from three sources —improved methods, improved conditions, and the greater application of the operative to the job.

Other objections which have been raised to production standards are that they tend to automatize the worker, kill his initiative, and reduce him to a mere cog in a vast machine, effects that are socially undesirable. While these results occur to some extent, they are more than outweighed by the numerous benefits to the worker which result

from production standards. Unfortunately, the scope of this book does not permit their discussion.

**The Phases in Determining Production Standards.** The work of determining production standards can be broken down into four phases:

(1) The standardization of conditions surrounding the work and affecting its performance.
(2) The observation of the operation and the recording of data relating to its performance.
(3) The analysis of the data and the determination of the standard.
(4) The application of the standard.

The preliminary work of standardization has been discussed previously.

The observation of the operation is the phase of time-study work that is usually associated in the mind of the average person with the determination of production standards. However, it is only one of the important steps in the work. It has to do with collecting the data from which the standard is derived. The operation is broken down into its elements. The time required for performing each element is then recorded with the aid of a stop watch. Any conditions directly or indirectly affecting the operation are noted.

The data are then analyzed to determine their character and quality. The time required for the performance of each element is determined. To the total of these elementary times various allowances for fatigue, personal needs, and other necessities are added.

The resulting standard must then be applied in the shop. This involves securing the confidence of the workmen, training them in the new methods, and other problems which require all of the tact and ability which the time-study analyst has at his command.

We have previously defined an operation as any course or series of acts, performed either by one workman or a group of workmen as a unit, which either adds one step to the complete process or in itself constitutes a complete process. In the above discussion, an elementary operation is any division or sub-division of an operation which corresponds to an individual motion and which has definite points of starting and stopping.

**The Equipment of the Time-study Analyst.** The equipment of the time-study analyst includes the stop-watch, time-study board, time-study sheet, and slide rule. The type of stop-watch that is usually used in time-study work is shown in Plate 16. The face of the watch is graduated in hundredths of a minute. The small dial is graduated in minutes so that the duration of elements whose time is less than thirty minutes can be read directly from the watch. The watch is

started by sliding the side plug up. If for any reason it is desirable to stop out time, the watch can be stopped by sliding the side plug down. When it is desired to start timing again, the watch can be started, without returning the hands to zero, by sliding the side plug up once more. When the timing has been completed, the side plug is pulled down and the hands snapped back to zero by pressing the crown. In addition to the type shown, there are various types of split-hand and duration-computing stop-watches.

Because it may be necessary to record a considerable amount of data in a short space of time, some orderly arrangement for recording the data in a manner that will facilitate their being worked up by the analyst after he has returned to his office, is desirable. Time-study sheets vary somewhat with each concern, depending on the method of time study in use, and the ideas of the time-study analyst in charge of the work. Fig. 53 shows one form of time-study sheet. The study is one of a stitching operation in a shoe factory. The complete cycle of elementary operations is the sum of "a," "b," "c," and "d." The time required for the operations, "Tie up case," "Record case no.," "Open work," and "Get machine ready," is a constant for each case regardless of the number of pairs therein. The "y," or necessary delay time, is finally applied as a per cent of the total net times, "a," "b," "c," "d," and "t." The foreman of the department inspects each case studied and passes on the quality of the work.

In taking a time study, the time-study analyst usually stands to the rear and left of the workman in order that he may not be in the workman's field of vision. If he were to stand in front of him, the analyst would be an influence tending to distract the worker's attention from the job, and in some instances to make him nervous and ill at ease. This nervousness might decrease the reliability of the results. The time-study board is constructed so that the stop-watch may be hung in the upper right-hand corner. It is held on the analyst's left forearm. He stands to the rear and left of the workman in such a position that the piece of work, the stop-watch, and the time-study sheet are in a straight line.

The analyst should be able to use a slide rule because of the great amount of data which must be computed.

**Classes of Time Studies.** Time studies may be classified according to the manner in which they are made and the type of work to which they are adapted. A convenient classification is (1) operation studies, (2) machine studies, and (3) job studies.

An operation study is one in which the elements of the operation are analyzed and studied for the purpose of determining a production standard for that particular operation. Inasmuch as the standard is

THE THOMPSON & LICHTNER CO, INC – ENGINEERS – BOSTON, MASSACHUSETTS

OPERATION Stitching Saddles PATT NO. A55-57 STUDY NO. SSS-12
OPERATOR S. Jones NO. 1029 MAT. Brown Calf NO PRS 9 PAGE 1
LAST NO. 223 MACH. Double Needle DEPT Fitting
CASE NO. 3259 START 9.20 STOP 9.37 ELAPSED TIME 17 Min. DATE 8/9/27
OBSERVED BY E. Lescault EXTENDED & CHECKED BY E. Lescault

QUALITY OF WORK DONE DURING STUDY ~~IS~~ SATISFACTORY SIGNATURE OF FOREMAN H. Small.

NOTES

| a | b | c | d | | h |
|---|---|---|---|---|---|
| 0 13 | 0.29 | 0 15 | 0.25 | | 0 82 |
| 0.14 | 0.28 | 0 14 | 0 25 | | 0 81 |
| 0 10 | 0 27 | 0 20 | 0 22 | | 0 79 |
| 0.08 | 0 25 | 0 16 | 0 21 | | 0 70 |
| 0 10 | 0 31 | 0 14 | 0 26 | | 0 81 |
| 0 12 | 0 24 | 0 15 | 0 22 | | 0 71 |
| 0 08 | 0 28 | 0 14 | 0 23 | | 0 73 |
| 0 14 | 0 26 | 0 14 | 0 23 | | 0 77 |
| 0 13 | 0 23 | 0 12 | 0 23 | | 0 71 |
| 0 10 | 0 27 | 0 16 | 0 22 | | 0 75 |
| 0 12 | 0.27 | 0 11 | 0 20 | | 0 70 |
| 0.11 | 0 22 | 0 13 | 0.20 | | 0 66 |
| 0 10 | 0 24 | 0 13 | 0 19 | | 0 66 |
| 0 09 | 0 21 | 0.14 | 0 21 | | 0 65 |
| 0 09 | 0 28 | 0 12 | 0 20 | | 0 69 |
| 0 12 | 0 24 | 0 12 | 0 21 | | 0 69 |
| 0 11 | 0.24 | 0 12 | 0 24 | | 0 71 |
| 0.12 | 0 26 | 0 12 | 0 21 | | 0 71 |
| 1 98 | 4 64 | 2.47 | 3.98 | | 13.07 |
| 18 | 18 | 18 | 18 | | 18 |
| 0 1100 | 0 2575 | 0.1371 | 0 2210 | | 0 7256 |

| SYMBOL | DETAIL ELEMENT | TOTAL TIME | NO EL | AV TIME | GOOD TIME |
|---|---|---|---|---|---|
| | Place | 1.98 | 18 | 0 1100 | |
| | Stitch 8" & Turn | 4 64 | 18 | 0 2575 | |
| | Stitch 2" | 2 47 | 18 | 0 1371 | |
| | Turn & Stitch 8" | 3.98 | 18 | 0.2210 | |
| | Complete Cycle | 13.07 | 18 | 0.7256 | |
| | Job Time | 1.09 | | | |
| | Trim | 1.68 | 18 | 0.0933 | |
| | UNNECESSARY DELAYS | | | | |
| | NECESSARY DELAYS | [illegible] | | | |

| ELEMENT | SYMBOL | WATCH READING | UNIT TIME |
|---|---|---|---|
| Open Work | J | 0.22 | 0.22 |
| Get Machine Ready | J | .58 | 0.36 |
| | a | .71 | 0.13 |
| | b | 1.00 | 0.29 |
| | c | .15 | 0.15 |
| | d | .40 | 0.25 |
| | h | | 0 82 |
| | a | .54 | 0.14 |
| | b | .82 | 0.28 |
| | c | .96 | 0.14 |
| | d | 2.21 | 0.25 |
| | h | | 0.81 |
| | a | .31 | 0 10 |
| | b | .58 | 0.27 |
| | c | .78 | 0.20 |
| | d | 3.00 | 0.22 |
| | h | | 0 79 |
| Oil 3.12 to 3 20 (0.08) | a | .08 | 0.08 |
| | b | 41 | 0.25 |
| | c | .57 | 0.16 |
| | d | .78 | 0.21 |
| | h | | 0.70 |
| | a | .88 | 0.10 |
| | b | 4.19 | 0.31 |
| | c | .33 | 0.14 |
| | d | .59 | 0.26 |
| | h | | 0.81 |
| | a | .71 | 0.12 |
| | b | .95 | 0.24 |
| | c | 5.08 | 0.13 |
| | d | 30 | 0.22 |
| | h | | 0.71 |
| | a | .38 | 0.08 |
| | b | .66 | 0.28 |
| | c | .80 | 0.14 |
| | d | 6.03 | 0.23 |
| | h | | 0.73 |
| | a | .17 | 0 14 |
| | b | .43 | 0.26 |
| | c | .57 | 0 14 |
| | d | .80 | 0.23 |
| | h | | 0 77 |
| | a | 93 | 0 13 |
| | b | 7.16 | 0.23 |
| | c | .28 | 0.12 |
| | d | 51 | 0 23 |
| | h | | 0.71 |
| Change Bobbin | Y | 87 | 0.36 |

| ELEMENT | SYMBOL | WATCH READING | UNIT TIME |
|---|---|---|---|
| | a | .97 | 0.10 |
| | b | 8.24 | 0.27 |
| | c | .40 | 0 16 |
| | d | .62 | 0.22 |
| | h | | 0.75 |
| | a | .74 | 0 12 |
| | b | 9.01 | 0.27 |
| | c | .12 | 0 11 |
| | d | 32 | 0 20 |
| | h | | 0.70 |
| | a | 43 | 0 11 |
| | b | .65 | 0 22 |
| | c | .78 | 0.13 |
| | d | .98 | 0 20 |
| | h | | 0 66 |
| | a | 10.08 | 0.10 |
| | b | 32 | 0.24 |
| | c | .45 | 0 13 |
| | d | .64 | 0.19 |
| | h | | 0 66 |
| | a | 73 | 0 09 |
| | b | .94 | 0.21 |
| | c | 11.08 | 0.14 |
| | d | 29 | 0.21 |
| | h | | 0 65 |
| | a | 38 | 0.09 |
| | b | .66 | 0 28 |
| | c | .78 | 0 12 |
| | d | .98 | 0 20 |
| | h | | 0 69 |
| | a | 12.10 | 0 12 |
| | b | .34 | 0 24 |
| | c | .46 | 0 12 |
| | d | .67 | 0 21 |
| | h | | 0 69 |
| | a | .78 | 0 11 |
| | b | 13 02 | 0 24 |
| | c | .14 | 0 12 |
| | d | .38 | 0 24 |
| | h | | 0 71 |
| | a | .50 | 0 12 |
| | b | .76 | 0 26 |
| | c | 88 | 0 12 |
| | d | 14.09 | 0 21 |
| | h | | 0 71 |
| Trim Shoes Apart | T | 15.77 | 1.68 |
| Tie Up Case | J | 16 07 | 0.30 |

*Courtesy—The Thompson & Lichtner Co.*

FIG. 53

A Time Study Sheet

chiefly of value in connection with that operation, the operation study has its greatest use in connection with the manufacture of standard products in large quantities, the operations remaining unchanged for considerable periods of time. Probably the majority of time studies are of this kind.

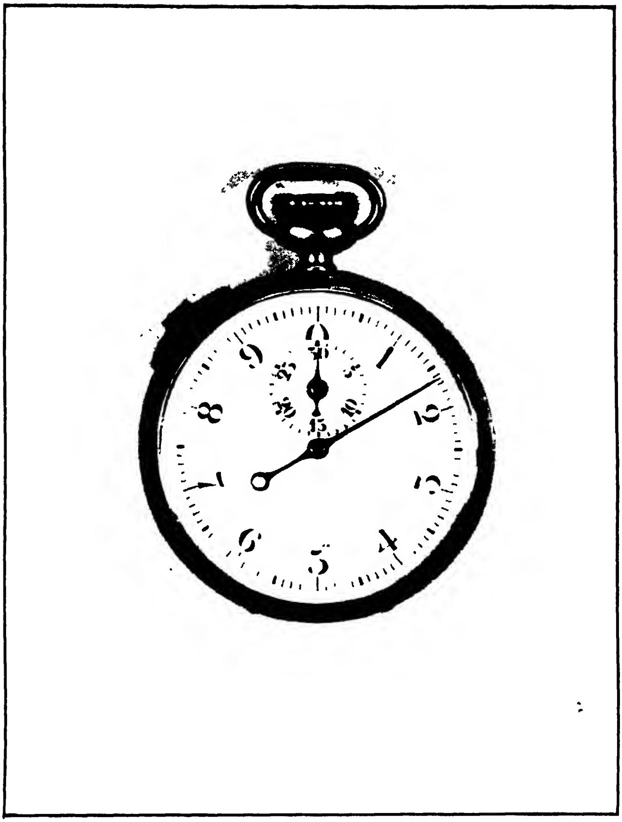
A machine study is one in which the fundamental operations performed on a given type of machine are analyzed and studied with a view to determining the time relations governing these operations. The standard for a particular operation performed on this type of machine is determined by summing up the times required for the performance of these fundamental elements in the operation plus the time required for machining and any allowances which may be necessary. While it is not as accurate as the operation study, the machine study is the most economical and satisfactory for work done in relatively small quantities, which uses certain specific types of machines, but has operations which vary somewhat with each job, although the general characteristics of the operations are similar.

A job study is one which is concerned chiefly with the analysis and study of the fundamental operations performed on a given class of work. In other respects, the method of attack is similar to that of the machine study.

**Standardizing Conditions.** The importance of the preliminary work of standardization has already been stressed. The purpose of this preliminary work is to survey the job and the conditions surrounding it, and to improve these conditions wherever possible in order that the workman and the machine may produce to the best advantage. The principal factors which affect the production standard are

(1) Material.
(2) Equipment.
(3) Quality of the product.
(4) Method of operation.
(5) The conditions surrounding the job, such as light, heat and ventilation.
(6) Methods and equipment for transporting materials and product.
(7) The workman.

The preliminary work is concerned chiefly with the first six of these factors. However, it affects materially the workman and his ability to produce. He is affected more directly by the work of time study and the application of the standards. Space will not permit any considerable discussion of these factors in connection with the preliminary standardization. Nevertheless, its importance will be realized when it is considered that variations in any one of many factors, such as the hardness of materials, may seriously depreciate the value of the standard. If a lot of material is processed, which is harder than



*Courtesy—The Stein and Ellbogen Co.*

PLATE 16

A STANDARD STOP WATCH

the material used when the time studies were made, it is probable that the time actually required for processing a given operation will be greater than the standard time. There is greater probability of tool breakage. The quality of the finish may be affected adversely. Standard conditions must be secured before production standards can be determined which can be recommended to the shop confidently as fair criteria for quantities produced. In addition to the above, the analyst may find it necessary to study other factors such as cost records, production records, wage rates, and other sources of information which will aid in determining the production standards.

The preliminary standardization may result in considerable savings from improved use and handling of materials, changes in machines, their locations, their mechanical parts and auxiliary equipment, and improved methods of processing the product. W. O. Lichtner[1] gives an interesting illustration of such savings in connection with the operation of cutting leather hides and furs for use in making overcoats. Before the operation was studied, it had not been considered possible to standardize the operation because each pelt was of a different shape and size and had various imperfections. A study of the operation showed that the experienced cutter always used the same general method for getting the greatest quantity of parts out of a given skin, although in most cases he did not realize it. It was found possible to standardize the operation and to obtain a more economical use of the pelts. Furthermore, the time required for training new cutters was considerably reduced. It is stated that the saving which resulted from this particular standardization was approximately $16,000 per year.

**The Approach to the Time Study.** The time-study analyst can accomplish the best results only when he has the cooperation of the organization. His success depends to a large extent on his ability to educate the organization to cooperate. This includes the executive staff, from the general manager to the foreman, and the employee. Usually, little or no attempt to interest the employee is made until the preliminary standardization has been carried to the point where it begins to show results. These results, in themselves, will tend to interest the employee and to secure his cooperation. Furthermore, if the executive organization is convinced of the desirability of developing production standards, there will be little difficulty in securing the interest and cooperation of the employee in most cases. The attitude of the department foreman is often the attitude of the employee. Similarly, the attitude of the foreman is often determined by the attitude of the executives above him. The cooperation of the executive organization

[1] *Time Study and Job Analysis*, by W. O. Lichtner, p. 50.

is necessary from the start, for without it little can be done to standardize conditions and methods. The better control of operations which is possible with accurate production standards, the increased production which results from the standardization of the physical factors affecting the job, the improved morale of the working force which results from a well-planned wage-payment system based on accurate production standards, the increased production which results from this improved morale and the wage incentives for increased production, the increased production resulting from a careful analysis of operations and the development of better methods of performing them, are some of the facts which may be used to interest the foreman and the organization in the desirability of developing accurate production standards.

It is desirable that some tangible results be shown as soon as possible because of their salutary effect on the organization. In this connection the choice of the department in which the work shall be started is important. A department in which the foreman is interested and desirous of cooperating, where the work is more susceptible to time study, and where there is an opportunity for quick returns, obviously is the ideal department in which to start the work. Before the work is started, it should be discussed with the foreman of the department in order that his attitude can be determined, the work explained to him, and his interest aroused. He should be approached by the head of the production organization preferably, because of the weight which his opinion has with the organization. If necessary, the time-study analyst can supplement in detail any explanations which this executive may give. Probably it may be necessary to assure the foreman that his position and authority in his department will not be affected adversely, that there will be no serious interference with production while the studies are being made, that a system of wage payment in proportion to production, based on accurate production standards, does not necessarily diminish the quality of the work, but, on the contrary, may increase it if it is properly handled, or to give other assurances of a similar nature. It should be pointed out that if increased production results from the work, his prestige in the organization will be enhanced.

After the preliminary standardization has been completed, the choice of the workman who is to be studied first is important. If the employee objects to being time-studied, there are many ways in which he can soldier and make the work difficult. He should be chosen with the advice and consent of the foreman. It is desirable to select a skilled workman, but not necessarily the most skilled workman in the department. Sometimes we find a man who is unusually gifted.

A standard based on his performance might be so high that the average workman could not attain it even with considerable training. Mr. Lichtner gives the following reasons for using a skilled employee:[1]

(1) His motions are more uniform.
(2) He works more steadily.
(3) He probably will use the best methods.
(4) He probably will adapt himself more readily to the new methods.
(5) The influence of the personal equation is less pronounced.
(6) For these reasons, the results obtained by a time study of a skilled employee probably will be more dependable.

**Motion Study.** Motion study refers specifically to the study of the employee's movements involved in performing the elementary operations. An analytical study of these elementary operations, with regard to the method of performing them and their relation to one another, and the character of the motions which the employee must make in performing them, should be made before the work of taking times is started. An analytical record of the present method should be made. This record should be studied to determine the correct practice. As a result of this study it may be necessary to change the order in which the elements are performed. If the worker is performing unnecessary movements, these must be eliminated. The study may show that changes in fixtures, the manner of storing the work at the machine or other changes, can be made profitably. Such changes must be made before the analyst starts to take times. Fig. 54 illustrates a form of analytical record for use in making a motion study.

The technique which we have described briefly should not be confused with what is called micro-motion study. While the same fundamental principles govern the study of the correct motions by either method, the technique of micro-motion is quite different and the more scientific.

**Taking the Time Study.** As previously discussed, the analyst records what is being done. The operation is broken down into its elementary operations. These elements are studied with a view to improving the manner in which they are performed. Then the time required for the performance of each element, as shown by the stop-watch on his study board, is recorded.

In selecting the elementary operations, as few motions should be included in each one as possible. If an element includes too many, it may be difficult to determine the causes of variations in the elapsed times for the element. If possible, the elementary operation should include only one motion with definite points of starting and stopping. However, this is not always possible, as the elapsed time for certain

[1] *Time Study and Job Analysis*, W. O. Lichtner, p. 154.

elements may be so short that it is difficult to time them accurately unless the analyst has great skill.

Mr. Dwight Merrick has developed a method which is interesting because of his statistical treatment of the elementary times.[1] The principles on which it is based are those underlying most successful methods. Fig. 55 illustrates a Merrick time-study sheet. After the operation has been analyzed into its elements, the elementary operations are listed in sequence at the left of the time-study sheet as shown. The stop-watch is started as the study begins, and runs continuously

Operation Name____________________

Operation No.________ Dept. No.________ Location______________ Foreman______________

| No. | Element | Left Hand | Both Hands | Right Hand | Posture | Remarks |
|---|---|---|---|---|---|---|
| | | | | | | |

FIG. 54
A MOTION STUDY SHEET

throughout the whole study. Each vertical numbered column contains a complete set of observations for the elements in the operation. The analyst must determine in his mind the exact point at which each element is completed, and the reading for that element recorded. The reading for the element must always be taken at that point. Otherwise, a variation in the readings is introduced which is a source of error. As the workman completes an elementary operation, the analyst's eye drops from the work to the stop-watch, noting the time, and thence to the time-study sheet on which the reading is recorded. The experienced time-study analyst can make and record these observations with remarkable speed and accuracy.

Some analysts time each element separately, a method known as

[1] *Time Study for Rate Setting*, by Dwight V. Merrick.

OBSERVATION SHEET

OBSERVER'S NAME Doncoe MACHINE NO. P. & W. Auto. #1530 DATE 3-17-18

WORKMAN'S NAME AND QUALIFICATIONS Deers, Samuel-#7437-Adjuster-Good

PART AND SIZE Model Enfield-Bolt Stop

| | DETAILED OPERATIONS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | TOTAL AVE. | MIN. SELECT. MIN. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Pick Up Piece And Wash Jaws | 06 0.06 | 06 1.76 | 04 3.16 | 03 4.52 | 04 [illegible] | 04 7.25 | 03 8.66 | 03 10.01 | 10 11.44 | 04 12.80 | 03 14.16 | 04 15.52 | 04 16.87 | 04 18.24 | 04 19.59 | 03 20.95 | 03 22.32 | 04 23.70 | 04 25.07 | 04 26.44 | 78 .041 | 03 .032 |
| 2 | Place In Jaws And Tighten. | [illegible] 0.15 | 06 1.82 | 05 3.21 | 06 4.58 | 05 5.93 | 06 7.31 | 06 8.72 | 05 10.06 | 07 11.51 | 05 12.85 | 07 14.23 | 06 15.58 | 06 16.93 | 04 18.28 | 07 19.66 | 08 21.03 | 05 22.37 | 06 23.76 | 06 25.13 | 04 26.48 | 110 .0579 | 04 .0452 |
| 3 | Tap With Hammer. Feed In. | 04 0.19 | 04 1.86 | 04 3.25 | 03 4.61 | 03 5.96 | 03 7.34 | 03 8.75 | 03 10.09 | 03 11.54 | 03 12.88 | 03 14.26 | 03 15.61 | 03 16.96 | 03 18.32 | 03 19.69 | 03 21.06 | 04 22.41 | 03 23.79 | 04 25.17 | [illegible] | 63 .0332 | .0259 |
| 4 | Table Forward | 07 0.26 | 06 1.92 | 04 3.29 | 05 4.66 | 05 6.01 | 05 7.39 | 05 8.80 | 05 10.14 | 05 11.59 | 05 12.93 | 05 14.31 | 05 15.66 | 05 17.01 | 05 18.37 | 05 19.74 | 05 21.11 | 05 22.46 | 05 23.84 | 05 25.22 | 05 26.59 | Machine Time | |
| 5 | Mill. | 1.34 1.60 | 1.13 3.05 | 1.13 4.42 | 1.11 5.77 | 1.13 7.14 | 1.11 8.50 | 1.10 9.90 | 1.13 11.27 | 1.11 12.70 | 1.13 14.06 | 1.10 15.41 | 1.10 16.76 | 1.12 18.13 | 1.10 19.47 | 1.11 20.85 | 1.09 22.20 | 1.13 23.59 | 1.12 24.96 | 1.12 26.34 | 1.12 27.71 | | |
| 6 | Return Table | 04 1.64 | 04 3.09 | 04 4.46 | 04 5.81 | 04 7.18 | 04 8.54 | 04 9.94 | 03 11.30 | 03 12.73 | 03 14.09 | 03 15.44 | 04 16.80 | 03 18.16 | 03 19.50 | 04 20.89 | 04 22.24 | 03 23.62 | 03 [illegible] | 03 26.37 | 04 27.75 | | |
| 7 | Loosen Jaws And Remove Piece. | 06 1.70 | 03 3.12 | 03 4.49 | 03 5.84 | 03 7.21 | [illegible] 8.62 | 02 9.96 | 04 11.34 | 03 12.76 | 04 14.13 | 04 15.48 | 03 16.83 | 04 18.20 | 03 19.53 | 03 20.92 | 03 22.27 | 04 23.66 | 03 [illegible] | 03 26.40 | 03 27.78 | 64 .0356 | 03 .0278 |

Speed Gears-$\frac{32}{38}$-103.9 R.P.M.

Feed Gears-$\frac{32}{38}$-.01314 Feed.

Operator Running 4 Machines.

Stroke On Machine-$1\frac{3}{8}''$

Spindle Speed-108 R.P.M.

Day And Night Man.

Material-Chrome Nickel Steel

Individual Deviations

1-1.37

2-1.45

3-1.11

4-

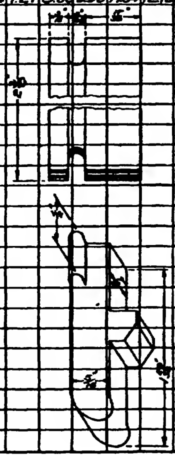
5-

6-

7-1.19

4 | 5.12

1.28



Courtesy—Mr. Dwight V. Merrick.

FIG. 55

A Time-Study Sheet

the repetitive method. Time-study experts, for the most part, favor continuous readings, for the reason that it is difficult to start and stop the watch exactly at the beginning and end of an elementary operation. A certain time must elapse between the reaction of the analyst to the movements of the machine or the workman, and his movement of the side plug to start or stop the watch. The repetitive method tends to waste the analyst's time, as he must wait for the same elementary operation to appear again in the cycle or he must time the elements out of sequence. Furthermore, the times for the elementary operations depend on one another to a considerable extent. The workman may unconsciously speed up on one element of the operation. If he does, it is probable that unconsciously he will slow down on the following element. In addition, the analyst may not observe an element exactly when it is completed. If this is the case the time for the element may be greater than it should be, and that of the succeeding element smaller. In some instances, the situation may be reversed. If the method of repetitive timing is used, these errors are not discovered readily. Furthermore, the continuous method gives a continuous record of all time within the period of the study.

The reading for each element is recorded opposite it, in the column for the particular set of readings which is being taken. The number of sets of readings which must be taken depends on the nature of the operation. If a number of irregular variables enter into the operation, obviously the study must continue for a longer time and more studies must be taken than if the operation is composed of a small number of short, regular elements.

After sufficient observations have been taken, the elapsed time for each element is computed by subtracting the recorded time for the preceding element from the recorded time for the element. The elapsed time is entered on the study sheet above the recorded time, as shown in Fig. 55.

The conditions immediately affecting the performance of the operation should be recorded on the reverse of the study sheet before the analyst begins to take times.

**Methods of Taking Elementary Times.** There are five stop-watch methods of taking elementary times. These are the continuous method, the repetitive method, the overall method, the accumulative method, and the cycle method.

The advantages and disadvantages of the first two methods have been discussed sufficiently in the preceding section.

In the overall method, time is recorded only for the operation as a whole. As no account is taken of elementary times, it is difficult to

determine the location and causes of variations in operation times. This method is not used except for checking time studies.

In some instances, the elementary operations will occur with such rapidity that it is difficult for a skilled analyst to observe them accurately. In such cases, either the accumulative or the cycle method must be used.

With the accumulative method, the analyst uses two or more stopwatches. Each watch is reserved for an element. With the beginning of the first element, the first watch is started. With the beginning of the second element, the second watch is started and the first watch is stopped simultaneously. This procedure is continued until readings on all the watches have been obtained. The time shown on the watches is then entered on the time-study sheet. The process is continued until sufficient readings for all of the elements have been obtained. A skilled analyst can get accurate readings of fast elements by this method.

With the cycle method, the analyst takes overall times of all of the elements in the operation less one. The watch runs continuously throughout the study. The time for each element is then computed by means of simultaneous equations. To illustrate, suppose that there are five elements in an operation. By the cycle method, their values would be determined as follows:

$$
\begin{array}{lrrrrrl}
(1) & a+ & b+ & c+ & d+ & & = .084 \text{ min.} \\
(2) & + & b+ & c+ & d+ & e & = .093 \quad `` \\
(3) & a+ & + & c+ & d+ & e & = .087 \quad `` \\
(4) & a+ & b+ & + & d+ & e & = .089 \quad `` \\
(5) & a+ & b+ & c+ & + & e & = .079 \quad `` \\
\\
(6) & 4a+ & 4b+ & 4c+ & 4d+ & 4e & = .432 \text{ min.} \\
(7) & a+ & b+ & c+ & d+ & e & = .108 \quad ``
\end{array}
$$

Eliminating against equation (7) to get the time for any one element,

$$
\begin{array}{rl}
a + b + c + d + e & = .108 \text{ min.} \\
= a \pm \quad \pm c \pm d \pm e & = .087 \quad `` \\
\\
(8) \qquad b & = .021 \text{ min.}
\end{array}
$$

Because of the greater time which elapses between readings, the average analyst can record continuous time with sufficient accuracy.[1]

**Analyzing Studies and Setting Standards.** When sufficient data have been obtained, it must receive further analysis and study in the time-study office before the production standard can be determined. This

[1] See *Time Study and Job Analysis*, by W. O. Lichtner, p. 165, for a more complete discussion.

phase of the work is quite as important, and requires as much, if not more, judgment and experience, than the work of taking times. Usually it is done under the supervision of an analyst of considerable skill and experience.

Three phases of the work of analysis can be distinguished. These are, (1) the analysis of the data, (2) the determination of the standard, (3) the classification and codification of the time-study data for future use in setting standards.

The elapsed times for each elementary operation must be computed if such computations have not been made during the course of the observations. These readings must be studied to determine their character and value. Unusual readings are eliminated. It will be noticed in Fig. 55 that certain elapsed times for some of the elements have been crossed out. The elapsed time for the element, "place in jaws and tighten," in column one, line two, has been marked out because obviously it is too high. Perhaps the worker unconsciously slowed down or the analyst made an error in observing the time. The elimination of values which are either too high or too low is a matter for the judgment and experience of the observer.

Abnormal values should be eliminated because otherwise an error is introduced, and as a result the final standard may be unfair either to the workman or to the company. The extent of such unfairness, of course, will depend on the degree of the error. The inattention of the operator, observational errors of the analyst, slight variations in the operative's method of performing the element, unconscious but appreciable changes in the operative's rate of production, irregular variables affecting the performance of an element, and many other factors, may cause abnormal elementary time values. In the case of irregular variables, the analyst should star on the study sheet the observation in which it occurs, note the nature of the variable, together with the time of starting and ending of the occurrence. Mr. Merrick feels that, in general, "minimum or maximum isolated items 25 per cent less or 30 per cent greater" than adjacent values should be eliminated.[1] However, the judgment of the observer is influenced by the importance of the element which is affected. As Mr. Lichtner points out, if the element constitutes 80 per cent of the total cycle time, the effect of abnormal values of that element may be very important. If it constitutes only 8 per cent of the total cycle time, the effect of such values may be relatively unimportant.[2] He states that in cases where the elements are nonrepetitive, or depend on factors which are in themselves variable to some degree and are not under the direct

[1] *Time Studies for Rate Setting*, by Dwight V. Merrick, p. 13.

[2] *Time Study and Job Analysis*, by W. O. Lichtner, p. 195.

control of the worker, or the elements occur in connection with group work, it may be advisable to retain abnormal values.

In addition to eliminating abnormal values, the operation method should again be studied to make certain that the best method is being used. In this connection, it is often profitable to study the nature and manner of variation of any variable factors which may have been disclosed by the study. Changes in the machine or the method of performing the operation may make it possible to eliminate these variables entirely. For example, in the operation of an automatic machine with a magazine feed, the material may clog in the feed pipe occasionally. Production stops until the operator loosens the material in the pipe and it starts to feed again. It may be possible, by some slight change in the design of the feed pipe, to eliminate this interference entirely.

When the data have been analyzed, the values for each element which are retained in the study are averaged. In the Merrick method, the minimum value for each element is selected. The average time for the element divided by this minimum time gives what is called the deviation factor. Referring again to Fig. 55, it will be seen that the average time for the element, "place in jaws and tighten," is 0.0579 minutes. The minimum time is 0.04 minutes. The deviation factor is 1.45. When deviation factors have been determined for all elements, they are averaged. Then the average time for each element is divided by the average deviation factor to get what are called the minimum selected element times. In the above case, the average deviation factor is 1.28. The average time 0.0579 divided by 1.28 gives a minimum selected time of 0.0452 minutes. Obviously, the minimum selected time more nearly represents the best effort that the operator is capable of making, rather than performance that can be sustained steadily throughout the working period without resulting in cumulative fatigue. Mr. Merrick believes that the use of the deviation factor is desirable because: (1) it aids in developing better methods. Those elements which have the greatest deviation factors usually offer the greatest opportunity for improvement; (2) The minimum selected times usually agree better than the average times in comparisons between the performance of good and average operators. He states that the normal range of the average deviation factor is between 1.20 and 1.30; (3) The deviation factor gives an approximate check on the allowance necessary to cover variations within the operation itself.

As opposed to the above method, a number of prominent management consultants base their standards on the average, median, or most frequent element values, abnormal times having been eliminated previously, but without any statistical correction such as has been described.

Production standards, based on such average times, are used successfully in a great many industries. Mr. Lichtner analyzes the studies on skilled, average, and unskilled workers to determine the correction which should be made to a study on an unskilled worker to reduce it to a basis which is comparable with a study of the same operation made on a skilled worker.[1]

While the work of analysis is extremely important, space will only permit us to indicate its nature and to emphasize its importance.

When the values for the elements have been determined, certain allowances must be made to cover necessary variable operations, fatigue, and personal needs. Whether minimum selected times or average element times are used, some additional time must be allowed, for the reason that all unnecessary time, for whatever reason, usually is eliminated in determining them. Obviously, if the sum of the times which were finally determined for each element were used as the production standard, the average workman could not reach and sustain such a high rate of production without endangering his health. The amount of the allowance will depend on a number of conditions which will be discussed later. It is sufficient to point out that different time-study methods require different allowances for the same job, performed under the same conditions. If we were to use minimum selected element times, the allowance would be one thing. If we were to use average element times, the allowance would be something different.

The production standard, expressed in terms of time, consists of the sum of the element times which have finally been determined as the basis of the standard, plus a certain percentage for necessary variable operations, plus a certain percentage for fatigue, plus a certain percentage for personal needs, changing time tickets, etc. This standard may be expressed as a time per piece or other physical unit. As previously stated, it should be expressed in units of time, rather than money, because such units do not change in value.

The final phase of the work is the classification and codification of the time-study data. In many cases this work is so important that it may be considered to be a distinct division of the work of time study. One of the objectives of the time-study section is to reach a position where the taking of operation studies will rarely be necessary. In the average shop a great many different operations are being performed. However, analysis of these operations will usually show that the elementary operations can be classified according to a relatively few

[1] Mr. Lichtner's technique for taking times and analyzing studies is quite different from Mr. Merrick's. His methods have been used successfully in different industries. The student will be well repaid for reading his book entitled *Time Study and Job Analysis*.

fundamental types. Combinations of these fundamental types make up the innumerable operations performed in the shop. When finally worked up, the data for the elementary operations should be classified and filed according to these fundamental types. Where possible graphs or formulæ should be worked up by which the time required for the performance of each fundamental type can be determined for each style, type, or model of product or machine. Such classification naturally shades into the fields of job study and machine study, which will be considered later. To illustrate, Mr. Merrick has found that in most metal-working establishments the elementary operations can be classified according to twelve fundamental types. These are:

(1) Preparing the machine for the work from a normal position.
(2) Landing the work in the machine or in place.
(3) Squaring and leveling the work to run true.
(4) Clamping and otherwise holding the work in place.
(5) Setting the tools for the cuts.
(6) Manipulating the machine to start a cut.
(7) Machining.
(8) Manipulating the machine at the end of a cut. (Reverse of 6.)
(9) Removing tools after completion of cuts. (Reverse of 5.)
(10) Loosening and removing clamps, etc. (Reverse of 4.)
(11) Removing work, returning it to its original position. (Reverse of 2.)
(12) Restoring the work place to its normal condition. (Reverse of 1.)

Eventually, when sufficient time-study data have been collected, it should be possible to set sufficiently accurate production standards for most new work coming into the shop, without actually making operation studies.

**Applying the Standards.** The effectiveness with which the production standards can be applied in the shop depends to a large extent on the thoroughness with which the preceding work has been done. If the standard has not been determined carefully and accurately, it may be necessary to make adjustments after it has been put into use. Whether the adjustment be in favor of the workman or the company, his confidence in the ability of the time-study section is weakened somewhat, and the difficulty of applying future standards is increased as a result.

The application of the standards can be divided into three steps—(1) the writing of definite instructions covering the method of performing the operation; (2) instruction in this method; and (3) checking the results of the standards.

The instrument which conveys to the shop the correct method of performing the operation is called the instruction card. It furnishes a permanent record of the correct method of performing the operation. In this connection, it has the function of a standard practice in that it tends to eliminate misunderstandings regarding the correct method,

and unauthorized changes in this method. It is a convenient record for determining the worker's efficiency, and the proper payment for increased production. It is a guide for the worker in the proper performance of the operation, and for his instructor in training him to meet the standard of production. It is a convenient record of the conditions surrounding the job, under which the standard was set.

The information on the instruction card can be classified into three groups—general information, information relating to conditions of the job affecting its performance, and the method of performing the

36A QUADRUPLICATE 40M 8-16 FILE ON JOB

PIECE WORK RATES—GUN DEPARTMENT ........191

SHEET NO. ....

JOB ........

ALL NEW RATES OR CHANGES IN RATES MUST BE REPORTED ON THIS BLANK AND SENT TO THE SUPT'S OFFICE.

THESE RATES TAKE EFFECT ........191

| MODEL | NAME OF PART AND STYLE | OPERATION No | OPERATION | PRICE PER 100 OLD | PRICE PER 100 NEW |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

APPROVED BY

........ SUPT OFFICE ........ SIGNED BY FOREMAN

*Courtesy—Winchester Repeating Arms Co.*

FIG. 56

NOTICE OF CHANGE IN PIECE RATES

operation. Under general information comes such items as part number, part name, operation number, drawing number, possibly the base rate for the operation, and similar data. Under conditions of the job, come such items as the name and description of the material, name and drawing number of any jigs, fixtures, or gauges to be used, the speeds and feeds at which the machine is to be run, a sketch of the piece showing the cut and the relation of the tools and holding devices, and other conditions which directly affect the performance of the operation. Under the operation method come such items as the list of the elementary operations, the standard time for each element, the allowances to the base time for the operation, per unit of product. Very

often a copy of the instruction card is kept in the shop office or the shop tool cage, and is issued to the workman with his work ticket or his tools for the job. Fig. 58 is an example of an instruction card.

In a great many cases, the best results from production standards will not be obtained if the workman is merely given an instruction card for his operation and is left to work out his salvation. The standard was set on the basis of the performance of a skilled operative. Possibly the sequence or the character of the elementary operations was changed. The workman must establish new thought habits. He must pass through a learning period which is apt to be trying until he has mastered the new method. He may try conscientiously for a considerable time without being able to meet the standard of production. Unless he receives instruction and encouragement from the analyst, he may become discouraged and quit. Often the analyst can clock the workman and locate the elements which are not being performed within the standard time. A little instruction in the performance of these elements may enable the workman to meet the production standard regularly. Once a few men are meeting them, the other men in the shop have greater confidence in the standards and will be more willing to attempt to meet them. One of the biggest savings from production standards sometimes comes from the increased skill and efficiency of the workmen, aside from any increased application to their work induced by a wage incentive.

To prevent deterioration of the standards and to discover those men who need additional instruction, the standards should be checked frequently. Some time-study departments regularly keep efficiency records for each workman in the shop.

When the men are performing the operation regularly within the standard time, we have completed an operation study and have applied it successfully in the shop.

**Machine Studies.** We have previously defined a machine study as one which is concerned chiefly with the analysis and study of the fundamental operations performed on a given type of machine, and the determination of the time relations governing these operations.

In most cases, considerably more preliminary investigation and analysis is necessary before standards can be set as a result of machine studies than is necessary before they can be set as a result of operation studies. After the necessary data have been collected, standards can be set more cheaply by means of machine studies. The standard developed as a result of an operation study applies only to that operation. It may be the more economical if the operation is standard and is performed on a standard part, manufactured continuously in quantity. Production standards for a wide range of operations performed on a

given class of machine may be set on the basis of the data gathered as the result of a machine study. The machine study is adapted to the needs of those industries which manufacture a line within which the product is subject to variations due to the demands of the customer. The fabrication of steel freight cars is an example of this. The company may specialize in the manufacture of steel freight cars, but the designs of the different railroad companies are constantly changing. However, the same types of machines are constantly used, and the fundamental operations performed on these machines do not change.

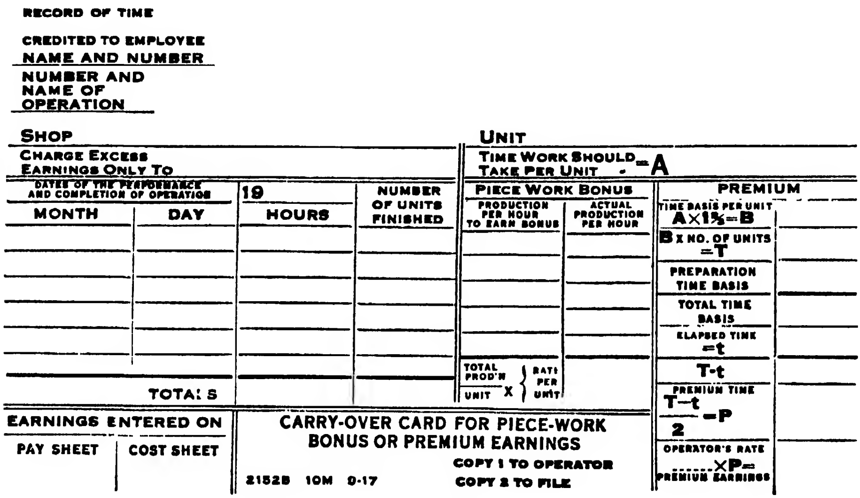

RECORD OF TIME
CREDITED TO EMPLOYEE
NAME AND NUMBER
NUMBER AND NAME OF OPERATION
SHOP
UNIT
CHARGE EXCESS EARNINGS ONLY TO
TIME WORK SHOULD TAKE PER UNIT = A
DATES OF THE PERFORMANCE AND COMPLETION OF OPERATION
19
MONTH
DAY
HOURS
NUMBER OF UNITS FINISHED
PIECE WORK BONUS
PRODUCTION PER HOUR TO EARN BONUS
ACTUAL PRODUCTION PER HOUR
PREMIUM
TIME BASIS PER UNIT A×1%=B
B X NO. OF UNITS =T
PREPARATION TIME BASIS
TOTAL TIME BASIS
ELAPSED TIME =t
T-t
PREMIUM TIME $\frac{T-t}{2}$=P
OPERATOR'S RATE ......XP= PREMIUM EARNINGS
TOTALS
TOTAL PROD'N UNIT X RATE PER UNIT
EARNINGS ENTERED ON
PAY SHEET
COST SHEET
CARRY-OVER CARD FOR PIECE-WORK BONUS OR PREMIUM EARNINGS
COPY 1 TO OPERATOR
COPY 2 TO FILE
21528 10M 9-17

FIG. 57
A RECORD OF EMPLOYEE'S EARNINGS

In most cases, a greater ability will be required to make satisfactory machine studies than will be required to make operation studies. The results will be better if the analyst has had considerable skill both in the operation of the type of machines which are being studied and in setting standards for them. He is better able to determine the manner in which the fundamental operations vary with different kinds of work. In the development of graphs and formulæ covering these variations, the analyst must exercise more than ordinary common-sense and analytical powers.

Briefly, the method of making machine studies consists, first, in making a study of the particular class of machine to determine what are these fundamental operations. Each fundamental operation is broken down into elementary operations and is the basis of operation studies. In making such studies, all observations are based on the normal position of the machine or the workman. In general, the

normal position is the usual position of the machine or the workman before it is set up for the operation. Each fundamental operation is studied under as wide a range of conditions as possible to determine the manner in which it varies. The data are set up in the form of charts or tables. When a standard must be set for a particular operation on a new job, the fundamental machine operations, and the conditions under which they will be performed, are determined. The time values to be allowed for the performance of each fundamental operation are then taken directly from the charts and tables for the machine on which the operation is to be performed.

In his book on *Time Studies for Rate Setting* Mr. Merrick gives the results of machine studies made on 30-, 36-, 60-, and 84-inch Gisholt boring mills. Reference to his list of fundamental operations for machine tools has already been made on page 195. The following data, taken from his studies, will illustrate the method of making machine studies.

PREPARATION OF MACHINE TO RECEIVE WORK [1]

| *Fundamental operations* | *Table* |
|---|---|
| Oil machine | 1 |
| Move rail by power | 2, 2A |
| Swivel head to angle | 3, 3A, 3B |
| Remove and replace tool post or bar | 4 |
| Change position of tool post | 5 |
| Set chuck jaws to line | 6 |
| Remove chuck jaws from table | 7 |
| Reverse chuck jaws on table | 8 |
| Move chuck jaws in or out of line | 9 |

The detail data for "change position of tool post," are as given on page 200.

In order to determine the proper time to allow for actual machining, data relating to the proper feeds and speeds at which the machine should be run with different kinds and conditions of work and material should be accumulated, and charted or tabulated for convenient use.

Fig. 58 shows an instruction card, made on the basis of machine-study data.

**Job Studies.** A job study is one which is concerned chiefly with the analysis and study of the fundamental operations performed on a given class of work. It is concerned with the determination of the time relations governing the performance of these operations. The job study differs from the machine study in that the latter accumulates data relating to the fundamental operations performed on a given

[1] *Time Studies for Rate Setting*, Dwight Merrick, p. 88.

*Table V*[1]

RAISE OR LOWER TOOL POST IN RAM
GISHOLT BORING MILL

| Details of operation | Raise post | | | Lower post | | |
|---|---|---|---|---|---|---|
| | Size of mach. (inches) | | | Size of mach. (inches) | | |
| | 42 | 60 | 84 | 42 | 60 | 84 |
| | Time in minutes | | | | | |
| 1. Obtain wrench from tool stand, walk to left side of machine | 0.09 | 0.09 | 0.10 | 0.09 | 0.09 | 0.10 |
| 2. Loosen hexagon clamping bolts | 0.12 | 0.17 | 0.20 | 0.12 | 0.17 | 0.20 |
| 3. Lay wrench on table | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 4. Pull pin, raise post | 0.04 | 0.05 | 0.05 | | | |
| 5. Pull pin, lower post | | | | 0.08 | 0.09 | 0.09 |
| 6. Pick up wrench | 0.02 | 0 02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 7. Tighten clamp in bolts | 0.22 | 0.26 | 0.29 | 0.22 | 0.26 | 0.29 |
| 8. Remove wrench to stand | 0.08 | 0.09 | 0.11 | 0.08 | 0.09 | 0.11 |
| Total time to raise post | 0.59 | 0.70 | 0.79 | | | |
| Total time to lower post | | | | 0.63 | 0.74 | 0.83 |

Tool required, open-end wrench.
Normal position of workman, in front of machine.

type of machine, and puts it in such shape that production standards for new jobs can be set without the expense and time required to make an operation study for the particular job. The former accumulates data relating to the operations performed on a given class of work in order that production standards can be set to accommodate changes in design, new designs within the class, or changes in conditions which do not change the characteristics of the work, without the necessity of making new operation studies in each case. With job studies, one is interested in determining the manner in which the characteristic operations vary with various types and sizes of work within the class under consideration.

The relation between the operations performed on these types and sizes of work within the class are expressed in the form of curves or formulæ. Where formulæ are used, they should be simple and easily

[1] *Time Studies for Rate Setting*, by Dwight V. Merrick, p. 98.

**INSTRUCTION CARD**

**Sketch**

**Date** 11-2-18 **Instr.Card No.** 1

**Name or Symbol Of Piece.** Bushing.

**Operation** Turn,face and bore.

**Dwg.No.** 178-1 **Mat'l.** C.I.

**Weight** 1,000# **Class** 13

**Mach.** 60" Gisholt Boring Mill - 1BV

| No of Items | Tool Set'g. & Mach Manip. | Detailed Instructions | No. of Cuts | Feed Per Rev. | Spind. Speed R.P.M. | Prep. Time In Min. | Unit Time In Min. |
|---|---|---|---|---|---|---|---|
| 1 | | Change job card at window | | | | 2.50 | |
| 2 | | Return to machine | | | | 1.50 | |
| 3 | | Move rail from normal - 5" (Table 2A) | | | | 2.98 | |
| | | Part 1. Turn Outside Diameter and face one end | | | | | |
| 4 | | Set chuck jaws to line(Tab.6) | | | | 4.85 | |
| 5 | | Hoist and land piece in chuck jaws,(Table 11A) | | | | | 2.00 |
| 6 | | Make piece run true,(Table - 12) | | | | 6.35 | |
| 7 | | Tighten jaws on work, (Table 12A) | | | | | 1.52 |
| 8 | (3.50)<br>(1.96) | Rough Turn (A) 9" run, (Tool PURC) | 2 | 0.08 | 4.75 | | 46.00 |
| 9 | (2.34)<br>(1.35) | Rough Face (B) 3¼" run. (Tool PURB) | 2 | 0.08 | 4.75 | | |
| 10 | 44.04 | Finish Turn (A - 8¼" run. (Tool PSFA) | 1 | 0.375 | 3.35 | | 6.80 |
| 11 | 2.80 | Finish Face (B) - 3½" run. (Tool PSFA) | 1 | 0.375 | 3.35 | | 2.80 |
| 12 | | Manipulate machine to set and start cuts.(Tables 17b-17A-17Da-17DC-17BB-17EA) | | | | | 15.99 |
| 13 | | Loosen jaws. (Table 19) | | | | | 0.66 |
| 14 | | Hoist and remove piece. (Table 19B-a) | | | | | 3.20 |
| 15 | | Clean table (estimated) | | | | 5.00 | |

*Courtesy—Mr. Dwight V. Merrick.*

FIG. 58

A Machine Study Instruction Card

Formula F-1 326
November 15,1925.

**Part:** Controller shafts.

**Operation:** Grind gear,handle,star wheel,and bearing fits.

**Machine:** Norton Grinder - Size 6" x 32" (2" stone) W.E. & M.Co. #23793.

**Standard Time:**

First Piece Time

.163 - T - 3(Each additional piece time).

Additional Piece Time

$$.0175X - .0016L_s - .0134Y - .0087(L_t - 1) - .0021$$

Where $L_s$ - Total length in inches of fits 1 7/8" or under.
$L_t$ - Total length in inches of fits over 1 7/8".
T - Values from Table 1.
X - No. of fits 1 7/8" or under.
Y - No. of fits over 1 7/8".

Table 1
True Stone.

| No. of fits per shaft. | Dec. Hours. |
|---|---|
| 1 | .1068 |
| 2 | .1068 |
| 3 | .1602 |
| 4 | .2136 |
| 5 | .2670 |

**Application:** This formula applies to rough and finish grinding of shafts up to and including six pounds where length of fit does not exceed eight inches,as done in section F-1 with methods and equipment as at present.

**Analysis:** Tools and equipment necessary are Norton Grinder,Micrometer,two dogs,socket wrench,air hose,table and diamond wheel dresser.

The shafts are delivered to and from the machine by a moveman or laborer. The operator places 25 shafts,on the average,on the table adjacent to the machine and cleans out the centers,using an air hose. The headstock and tailstock are adjusted to the length of the shaft and the trip dogs are set. The diamond dresser is placed in position and the wheel dressed;the micrometer,dog and wrench are placed on the table. The shafts are removed from the table by the operator after grinding.

*Courtesy—The Westinghouse Electric & Mfg. Co.*

FIG. 59

A Job Study

solved. They should cover, with sufficient accuracy, every job and condition of work that falls within the class. Their solution should not require information which is not readily available or which cannot be obtained with a minimum of difficulty. They should be so constructed that the manner of their solution is readily evident. If possible, their solution should not require more than a knowledge of high school mathematics.

Machine studies undoubtedly are of greatest use in connection with machine operations on work which is not entirely standard. Job studies are of greatest use in connection with work which is standard in so far as the fundamental characteristics of its class are concerned, but the details of these characteristics may vary with individual items within the class.

Like machine studies, a considerable amount of data must be accumulated before production standards can be set on the basis of job studies. The analysis of operation relations and the development of curves or formulæ covering the manner of their variation require a higher type of time study talent than is required for operation studies.

In making a job study, it is necessary to classify the operations performed on all work within the given class according to those elements for which the performance time is constant for all types within the class and those for which the performance time varies with each type. In the case of variable operations, it is necessary to determine the common basis on which they vary. Inasmuch as a definite line of products is being studied, time required for the same operation performed on parts for different sizes of the product will usually vary in some definite manner. It is probable that the time required for a number of operations will depend on the same variable. Such operations should be grouped together. Operation studies are made on different sizes of a part, covering the range of the class. From these data, the time relations for the different operations are determined.

Fig. 59 shows the first of a number of sheets covering the grinding operations on controller shafts. In grinding the bearing surfaces of the shafts, or bearing "fits" as they are termed, those fits which are 1⅞ inches long or less are "slab-ground." In other words, the table of the grinding machine does not travel. The grinding wheel, which is about two inches wide, is merely run up against the bearing surface. Each fit requires two operations—rough grinding and finish grinding. On the first operation, gauging is allowed once for every eight fits ground, and the second operation once for every four fits ground. On the basis of the above data, the time per fit for handling and gauging is:

$$2(E + F + G + I) + \frac{J}{8} + \frac{J_1}{4} =$$
$$2(.00063 + .0010 + .00037 + .0009) + .00036 + .00084 =$$
$$.0070 = \text{A constant.}$$

The meaning of the symbols and their time values are shown in Fig. 60. To illustrate, E represents the elementary operation, "pick up shaft." The time per fit for this element is .00063 hour. It is derived from data obtained by time-study S-1. For slab-grinding, a curve for rough grinding time was plotted by using actual points obtained from time studies covering a representative number of jobs, using the length of fit in inches as the abscissa and the time in hours as the ordinate. A similar curve was plotted for finish slab-grinding. The graphical sum of these curves combines the rough and finish grinding time for slab-grinding. The slope of this curve shows the grinding time for a half-inch length of fit to be .0113 hour and also that the grinding time increases .0016 hour per inch. Therefore the time for slab-grinding per fit is:

$$.0113 + (L_s - \tfrac{1}{2}'')\,0.0016 = .0113 + .0016L_s - .0008 =$$
$$.0105 + .0016L_s, \text{ where } L_s \text{ is the length of fit in inches.}$$

The grinding time factor plus the handling and gauging time factor is:

$$.0105 + .0016L_s + .0070 = .0175 + .0016L_s,$$

the grinding, handling and gauging time per fit. Therefore, the total of such time for X number of fits is:

$$.0175X + .0016L_s,$$

the first two factors in the expression for additional piece time. $L_s$ is the total length in inches of all fits of 1⅞ inches or under.

If a new controller shaft, having the same fundamental characteristics, is designed, the standard base time for the grinding operations can be determined without making complete operation studies. While the initial expense is greater, job studies are less expensive than operation studies. For a specific case, the standard set on the basis of job studies is not as accurate as the standard set on the basis of an operation study. However, it is sufficiently accurate for all practical purposes.

**Fatigue Allowances.** In connection with the discussion of setting standards on the basis of operation studies, it was pointed out that certain allowances must be added to the standard times for the elementary operations in order to bring the standard within reach of the average workman. Of these allowances, probably the fatigue allowance is the most difficult to determine.

Formula F-1 #26
Sheet #3.

Table Of Details.

| Symbol | Description Of Operation | Dec. Hours. | Ref. |
|---|---|---|---|
| A | Place shafts on table. Clean & oil centers. | .00145 | S-5 |
| B | Set two heads for length | .0302 | S-12 |
| C | True up stone (per fit) | .0534 | S-13 |
| D | Set trip dogs | .0244 | S-13 |
| E | Pick up shaft | .00063 | S-1 |
| F | Put shaft in machine | .0010 | S-10 |
| G | Start table and head | .00037 | S-2 |
| H | Rough grind and change dog | Curve #1 | |
| I | Stop table and head, remove & lay aside | .0009 | S-11 |
| J | Rough gauge | .0029 | S-7 |
| $H_1$ | Finish grind and change dog | Curve #2 | |
| $J_1$ | Finish gauge | .0034 | S-9 |
| K | Remove shafts from table | .0006 | S-13 |
| R | Reverse table | .00036 | Form F-1#1 |
| T | Table travel per inch | .00048 | S-4 |
| As | Get job and drawing | .0500 | Form.F-1 #1 |
| Bs | Get time slip | .0400 | " " " |
| Cs | Mark time on slip | .0178 | " " " |
| Ds | Study drawing | .0250 | " " " |

Time Studies.

| NO. | Date | Taken By |
|---|---|---|
| S-1 | 12-12-24 | L.W.Y. |
| S-2 | 1- 5-25 | " |
| S-3 | 1-28-25 | " |
| S-4 | 1-31-25 | " |
| S-5 | 1- 5-25 | " |
| S-6 | 12-16-24 | " |
| S-7 | 1-17-25 | " |
| S-8 | 2-11-25 | " |
| S-9 | 2-11-25 | " |
| S-10 | 2-18-25 | " |
| S-11 | 2-17-25 | " |
| S-12 | 11-11-25 | " |
| S-13 | 11-17-25 | " |

*Courtesy—The Westinghouse Electric & Mfg. Co.*

FIG. 60

A DATA SHEET FOR A JOB STUDY

Fatigue is the result of accumulations of poisonous wastes in the system. These wastes are produced by the breaking down of tissue in the body, as the result of excessive expenditures of energy. If they are produced more rapidly than they can be eliminated naturally by the body, they accumulate and produce a deadening effect on the mind and body of the workman which tends to slow him up and to reduce his production. If the accumulations are so great that they cannot be eliminated from the worker's system during the hours of leisure and rest, he comes to work with a residue of the previous day's fatigue wastes. To this will be added the wastes produced as a result of the present-day's work. If this is the usual condition of his work, we have a case of cumulative fatigue which eventually will result in a serious case of fatigue poisoning. If continued long enough it may result in a permanent deadening of his mental faculties, and the lowering of his productive capacity. Obviously, such a condition is detrimental to the best interests of society, the employee, and the employer. Therefore, a proper fatigue allowance in the production standard is highly important.

Objective measures of fatigue are largely lacking. The problem is human rather than material, and quantitive measures of the causes and effects of fatigue are difficult to obtain. Some work has been done by industrial physicians to determine the relation between vascular reactions and fatigue, with a view to developing some objective measures, but as yet such methods do not seem to have been developed to the point where they are of practical value in the day-to-day work of time study. Today, most methods for making fatigue allowances are the results of analyses of the relations of specific production standards to the production of men actually working under them. This method has proved to be practical and reasonably satisfactory.

Industrial fatigue is a complex problem because of the large number of factors which may cause fatigue, many of which are difficult to control. Poor lighting may cause glare, eyestrain, and fatigue. Poor ventilation hinders the natural elimination of fatigue poisons from the system. The class of work may require great skill, constant application, or it may develop nervous tension, all of which may produce fatigue. The relation of machine time to handling time in performing an operation, the amount of rhythm that can be developed in performing it, the posture of the worker, the monotony of the job, and many other factors may enter into the operation and affect the relation between its performance and fatigue.

Industrial engineers have recognized the importance of fatigue and its effect on production. As a result, many methods of reducing fatigue have been used. One method is the use of rest periods. Sometimes certain departments, where fatigue is an important factor in the

work, are closed down for a short rest period, usually about ten minutes, in the middle of the morning session and again in the middle of the afternoon. All work is stopped and the men are urged to relax and get their minds off their work as far as possible. The purpose of this rest period is to break up the monotony of the work and to give the worker's system a chance to eliminate, partially, the fatigue poisons which have accumulated. Obviously, such rest periods must be taken into account in setting production standards. Otherwise it is difficult to get the cooperation of the men in the shop, particularly if they are working under some system of wage payment in proportion to production. If such cooperation is not obtained, they will attempt to ignore the rest period and work through it. Where fatigue is an important factor in production, the introduction of rest periods may actually increase production. In addition to rest periods, improved seating devices, which can be adjusted to the work to improve the worker's posture, have been developed in some cases. Interchanging operators on similar jobs in order to reduce the monotony of the work has been advocated. This is not always possible because the characteristics of the job may not permit it. The Newark works of the Westinghouse Electric and Manufacturing Company has permitted the playing of phonographs in the shop as a means of relieving monotony.[1] These are only a few of the methods that have been tried to reduce the fatigue factor in production. Under certain circumstances they may be helpful.

Most time-study specialists have accumulated data from which they have developed tables or formulæ to enable them to determine the proper fatigue allowances to be made for various classes of work performed under various conditions. Such tables or formulæ are developed for use with their particular methods of time study. Mr. Carl Barth has developed a fatigue formula which can be used to determine fatigue allowances for light machine-tool work performed under average shop conditions. This formula was developed as the result of his analysis of a large volume of time-study data, accumulated by Mr. Merrick, covering a wide range of machine-tool work. Mr. Barth found that for machine-tool work, the fatigue allowance is controlled largely by the relation between the ratio of the handling time to the machine time and the minimum selected cycle time. By handling time is meant the time required by those hand operations performed in connection with the operation of the machine, exclusive of those which are concerned solely with the preparation of the machine for the operation. Placing a new piece in the machine is an example of such handling time. Mr. Barth's formula is given on the following page:

[1] "Where Music Aids Manufacturing," by H. E. Miller, *Manufacturing Industries*, October, 1926.

$$P = 20 + \frac{49.5 - 0.325C}{\sqrt{0.376 - 0.0000216C^2 + T}}, \text{ in which,}$$

P = Percentage allowance.
C = Percentage of handling time in the minimum selected cycle time.
T = Minimum selected cycle time in minutes.

The allowances obtained with the above equation are not strictly fatigue allowances. They are allowances which not only include fatigue, but also the additional time necessary to bring the standard within the reach of the average worker.

The method of determining allowances or of determining the value of the constants in the above formula for a particular shop is a matter which is too technical to come within the province of this book.

In addition to the percentage allowances for handling time, obtained by the above equation, Mr. Merrick adds 25 per cent to machine time, hand feed; 5 per cent to machine time, power feed; 25 per cent to preparation time; and 2½ per cent to the total time to cover washing, oiling, and personal needs. These allowances apply particularly to light machine tool work, performed under good shop conditions. Other types and conditions of work would require different allowances. For instance, heavy work and high temperatures would require considerably greater allowances for handling time, machine time hand feed, and possibly for the others. Work in a grinding-room in which the air is filled with emery dust would require greater allowances. These examples merely emphasize the fact that allowances must be developed to meet the requirements of the work and the conditions under which it is performed. The allowances may vary from 20 per cent to 100 per cent of the standard elementary times, depending on conditions.

The introduction of scientific management and standardization in themselves affect and usually reduce the allowances which must be made. Where time and motion studies are properly made, the best methods of performing an operation are developed. These usually involve the least number of motions and the smoothest sequence of their performance. This tends to reduce fatigue. A well-organized employment department can do much to reduce the effects of fatigue on production by properly selecting employees with regard to the mental and physical requirements of the job.

**Verifying the Standards.** Even when the best time-study methods have been used, there will be times when apparently the workman is unable to reach or sustain the production standard. In such cases, it will be necessary to verify its accuracy. The workman's inability to maintain the standard rate of production may be due to a number of reasons, such as lack of skill, changed conditions surrounding the job,

machine trouble, too much nonproductive time, or incorrect time study. Particularly in the case of operation studies, this inability may be due to some irregular operation which may not have been considered because the study did not extend over sufficient time to bring it out.

Perhaps the workman is taking too much time in the performance of certain elements. Possibly he is not using exactly the kind and sequence of elements that are prescribed in his standard instructions for the job. When the cause of the inability to meet the production standard is in such factors, verifying the standard may involve only a check of the method and time of performing the elementary operations. If such is the case, it may not require a great amount of time, aside from the time of instruction in the proper method.

If the cause is due to some irregular variable beyond the control of the worker, such as intermittent machine trouble or some necessary irregular operation which was not considered in the original study, the location of the cause may require considerable time. Studies must be taken, extending over a sufficient length of time to insure that all irregular variables are included. In some cases this may mean that the studies must be continued for a number of days. When no new irregular variables are appearing and those which have been noted have repeated themselves a sufficient number of times to furnish adequate data for their study, the study may be concluded.

The method of verifying the study is not exactly the same as the method of making an operation study. The data are taken by the method of continuous times. In recording data, it is desirable to separate hand time, machine time, and irregular operations in order to facilitate the study of their characteristics. If possible, elementary times should be computed as the study progresses. If this is done, it is possible to note the trends in these classes of times, which may throw considerable light on the cause of the worker's inability to meet the production standard. When the study has been completed, the handling time, machine time, and the times for the various irregular operations are totaled and divided by the number of pieces produced to get the actual time per piece. Comparison is then made with the original standard to locate the trouble.

The following hypothetical case will serve to illustrate the method of making a check study. The operation is milling a shoulder on a piece of steel. It is part of the process of manufacturing a steel part that is assembled into a standard product, manufactured in large quantities to stock. The table of the milling machine is returned automatically to its original position after the completion of a cut. Probably the operator would tend more than one machine. However, to simplify the case, it is assumed that he does not. The operator has been unable regularly to make the production standard shown as follows:

| *Operation elements* | *Std. time, min. per piece* |
|---|---|
| Remove dull cutters, set and adjust with sharpened cutters........ | .001 |
| Pick up tray of work and place on bench........................ | .010 |
| Pick up piece and place in fixture............................ | .035 |
| Tighten fixture and throw in power.......................... | .032 |
| Mill shoulder.............................................. | .635 |
| Return table to original position............................ | .116 |
| Remove piece from fixture and place in tray.................... | .038 |
| Wash chips from fixture with soda water...................... | .026 |
| Remove tray of finished work................................ | .010 |
| Total cycle time............................................ | .903 |
| Allowance on machine time (0.751 min. @ 5%).................. | .038 |
| Allowance on hand time (0.131 min. @ 40%).................... | .052 |
| Allowance on preparation time (0.021 min. @ 25%)............... | .005 |
| | .998 |
| Allowance of 2½% for washing and oiling....................... | .025 |
| Time per piece.............................................. | 1.023min. |

A check study was taken, covering the greater part of a day's operation. The manner of taking the data is shown on the form given below:

CHECK STUDY

| El. symb. | Hd. time | Mch. time | Var. op. | El. symb. | Hd. time | Mch. time | Var. op. | Remarks |
|---|---|---|---|---|---|---|---|---|
| a. | Pick | up pie | ce and | place | in fixt | ure. | | |
| b. | Tight | en fix | ture | and | throw | in | power | |
| c. | Mill | shoul | der. | | | | | |
| d. | Retu | rn tabl | e to | origin | al posi | tion. | | |
| e. | Remo | ve piec | e from | fixture | and pl | ace in | tray. | |
| f. | Wash | chips | from | fixture | with | soda | water. | |
| PT. | | | .23 | | .04 | | | PT—Pick up tray |
| | | | | f. | 1.19 | | | and place on bench. |
| | .05 | | | | .06 | | | |
| a. | .28 | | | a. | 1.25 | | | |
| | .04 | | | | .05 | | | |
| b. | .32 | | | b. | 1.30 | | | |
| | | .66 | | | | .68 | | |
| c. | | .98 | | c. | | 1.98 | | |
| | | .12 | | | | .14 | | |
| d. | | 1.10 | | d. | | 2.12 | | |
| | .05 | | | | .05 | | | |
| e. | 1.15 | | | e. | 2.17 | | | |
| | | | | | .03 | | | |
| | | | | f. | 2.20 | | | |

It was found that the workman's inability to meet the standards was due, in part, to his slowness in performing the hand operations, and to the fact that the work was not being piled at the machine as originally planned. The analysis of the data relating to the irregular operation element, "pick up tray and place on bench," was as follows:

***Put up Tray and Place on Bench***

| | |
|---|---|
| Number of pieces | 410 |
| Total element time taken | 21.32 min. |
| Time per piece | .052 " |
| Selected time for the element | .010 " |
| Allowance of 25% for preparation time | .003 " |
| Standard time for the element | .013 " |
| Unnecessary time taken | .039 " |

The above example is merely an illustration. In most cases where a check study is necessary, the difficulty would not be so obvious or the solution so simple.

**The Qualifications of the Time-study Analyst.** In most cases a complete staff of time-study men can not be imported into the plant. Usually, the head of the time-study section must select men from the organization and train them for his work. The question then arises as to the qualifications and characteristics of a good time study man which should be present in such candidates for training as far as possible.

The foregoing discussion of the work of setting production standards should indicate that its technical nature places it as much in the field of engineering as in the field of management. Practical experience with the processes and tools that are being used is decidedly helpful, although not necessarily a prerequisite. At least, the candidate should have mechanical sense. Otherwise his suggestions are likely to be impractical, and cause the loss of respect of the workmen, which may be fatal to his success. He should have good analytical abilities, combined with initiative, tenacity, and common sense. Often he must rely on his own resources to develop better methods and convince the workmen and his superiors as to their value.

The close contact with the operative and the nature of his work makes it possible for the time-study analyst to work a great deal of good or harm. Standards should not be forced on the workers and minor executives. Therefore, personality, courtesy, and tact, combined with the courage of his convictions, are necessary to gain their cooperation. In addition, a thorough knowledge of and skill in the technique of time study is as essential in getting their respect as it is in carrying on the actual work of time study.

Accuracy is a prime prerequisite. The time-study man is constantly

engaged in the collection and analysis of a great amount of detail data. Often his computations involve small fractions of minutes. Slight errors in computing may cause serious errors in the production standard, which may lay the time-study section open to the censure of the shop.

Neither the college graduate nor the practical shop man is entirely satisfactory as raw material for a time-study man. The first has highly developed analytical powers and greater possibilities for development. Usually he has a good scientific foundation and, in the case of engineering graduates, good technical training. The practical shop man may be bound by shop traditions regarding the best methods of doing work and reasonable standards of production. The college graduate has not had these ideas ingrained into him. On the other hand, he often lacks experience and suffers from an unjustifiable feeling of superiority.

The practical shop man probably will lack the good qualities of the college man, but he has the advantage that he has had extensive practical experience with the work that is being studied, and he may be able to work with the men better for the reason that he has their point of view.

The ideal candidate is the college graduate who has the qualities which have been mentioned previously and who has had considerable practical shop experience. Obviously this is a combination of qualities which is rarely found. It is chiefly an ideal measuring stick. In addition to the technical difficulties of his job, the time-study man sometimes must work against the criticism of the men and the organization until his work has proved its worth. His job is likely to be a trying one. Therefore, it is desirable that the time-study analyst have the above qualities in the highest practicable degree.

**Micro-motion Study.** Micro-motion study "consists of recording motions by means of a motion-picture camera, a clock which will record different times of day in each picture of the motion-picture film, a cross-sectioned background, and other devices for assisting in measuring relative efficiency and wastefulness of motions." [1] Micro-motion study is the most scientific method of determining production standards. Mr. Frank Gilbreth and Mrs. Gilbreth, who developed the method, advocated the use of a room in the plant, reserved for micro-motion research, in which machines and equipment can be set up for the study of operations. They felt that a more thorough and satisfactory study of operations could be made if it were conducted away from shop influences. In the shop there is a tendency to be influenced unduly by customary methods and conditions.

[1] *Applied Motion Study*, by F. B. and L. M. Gilbreth.

An important item of equipment is the "micro-chronometer." This is a fast-moving clock, preferably with a black face, white divisions, and white hands. Usually the clock hand revolves once in three seconds and has 100 divisions. It can be read to half-hundreds of three seconds, or 1/4,000 of a minute. They are sometimes constructed to record much smaller divisions of time.

In the micro-motion laboratory, a certain type of machine for performing an operation is set up. In back of the machine is a large cross-sectioned background. By means of the micro-motion camera, the workman is photographed while performing the operation. The micro-chronometer is set up within the field of vision of the camera. After the study has been completed and the film developed, it is projected on a screen and the elementary operations are studied in detail. The cross-sectioned background shows the relative distances through which the motions are made. The micro-chronometer shows the time taken in making them. Obviously the operation can be analyzed more accurately than by the stop-watch method. As a result of the study, it may be found necessary to change the character or sequence of the operation elements. After the correct method has been worked out, the operation is rephotographed. The standard is determined, and an instruction card, showing the conditions under which the operation should be performed, the operation elements, the time allowed for each element, fatigue, and other allowances, and similar information, is written.

In analyzing the operation, an attempt is made to reduce the number of variables affecting the operation to a minimum. These variables are grouped in three classes [1]—(1) variables of the worker, such as anatomy, brain, contentment, etc.; (2) variables of surroundings, equipment, and other physical factors, such as appliances, clothes, colors, etc.; and (3) variables of motion such as acceleration, automaticity, effectiveness, etc.

According to the Gilbreth theory of motion there are seventeen standard motions elements. These elements, called "therbligs," are listed below:

1. Search—locating an object or place with the eye.
2. Find.
3. Select—reaching for an object.
4. Grasp.
5. Transport loaded—moving the object to position.
6. Position—locating the object in position.
7. Assemble—bringing several objects together.
8. Use.
9. Disassemble—the reverse of assemble.

[1] *Applied Motion Study*, by F. B. and L. M. Gilbreth.

10. Inspect.
11. Pre-position for next cycle.
12. Release load.
13. Transport empty—removing the hand, the reverse of transport loaded.
14. Rest for overcoming fatigue.
15. Unavoidable delay.
16. Avoidable delay.
17. Plan—determining the next step in the operation.

In some cases, all of these therbligs will not be present in the operation. These elements are recorded by the camera as they are performed, and are studied later in detail.

In some cases, what is termed a cyclograph is made. Small electric lights are attached to the fingers, head, and elbows of the worker. A photographic dry plate is exposed during a few cycles of work. When a print of the plate is taken, the motions appear as lines of light, crossing and recrossing one another. When an interrupter is placed in the light circuit, the making and breaking of the circuit results in dotted lines on the print. If the rate at which the circuit is being interrupted is known, the number of these dots in the line of a given motion indicates the time taken by the motion. At first, a cyclograph of the operation is usually a maze of lines with no apparent pattern. Gradually, as the method is improved and operator acquires skill in the new method, succeeding cyclographs will acquire a simple definite pattern.

If the cyclograph is taken with a stereoscopic camera, three dimensions are approximated. Such a cyclograph is useful when it is desirable to make a wire model of the motions. The advantages claimed for motion models are that they furnish the learner with a tangible example of the motion, are a permanent record of the motions for future study, and they tend to get the worker into the habit of thinking in terms of elementary motions.

Finally, the operation is recorded in the form of a motion cycle chart. Time, in thousands of a minute, is recorded at the left of the chart. The various members of the body are listed horizontally across the top of the chart. Under each member are listed the therbligs in which they participate, opposite the time when they occur. The nature of these therbligs is indicated by mnemonic symbols. The length of time which these therbligs consume is shown by colored lines drawn vertically under the proper members. The colors also indicate the nature of the therbligs. The advantages claimed for the chart are that it indicates graphically the extent to which each member participates in the operation. It shows the nature of this participation. As a result, the opportunities for reducing fatigue and improving the operation method are more easily seen. Finally, the motion-cycle

chart also serves as a permanent record of the manner of performing the operation.

Micro-motion study methods have not been used as widely as stop-watch methods. To the majority of manufacturers the method seems to involve unnecessary refinement and expense. They feel that they can get satisfactory standards by the stop-watch method. The proponents of micro-motion study feel that the greater savings resulting from a more intensive study of the operation more than offset any additional expense. In some cases where standards have been developed under laboratory conditions, the workers have felt that they were not entirely fair, that the standards should be developed under actual shop conditions. This objection probably is not valid, but the attitude of the men is a factor which must be considered. Micro-motion study is not inherently a laboratory method. In many cases, studies can be and are made in the shop. The micro-motion methods have been used successfully in a number of plants throughout the country.

# CHAPTER XIV

## MAINTENANCE CONTROL

**The Purpose of the Maintenance Department.** The purpose of plant maintenance is to maintain the efficiency of plant and equipment to anticipate and prevent, as far as possible, interruptions to production due to machine breakdowns or equipment in poor condition. Such interruptions cannot be anticipated entirely, and will occur regardless of the excellence of the maintenance work. When they do, the maintenance department must make the repairs promptly and get the machine or equipment into production at the earliest possible moment.

By properly organizing the maintenance work, considerable savings and increases in efficiency can be made in the average plant. Usually the work is in the hands of a good mechanic who often is called the master mechanic. When he is notified of a machine breakdown by the foreman of a department, he sends one of his men to the department to repair the machine. Probably the mechanic will look the job over, and return to the maintenance shop for the tools that he should have brought in the first place. While the necessary repairs are being made, the production of the machine is lost, the overhead which this production should absorb increases operation costs, the wages of the workman for the time during which the repairs are being made must be charged to some idle time account which increases the overhead of the shop. Probably the cost of the repairs will be greater than it would have been had the break been anticipated. In such a shop it is not likely that much attention will be paid to belt tensions or the conditions of belts until they actually begin to slip or break. When the windows get so dirty that poor light interferes with the work, some one may see that they are washed. These are only a few examples of the wastes which result from poor plant maintenance.

**The Organization of the Maintenance Department.** Although the work of the maintenance department has a direct and important relation to continuous production, it is usually handled by a separate organization rather than the regular production organization. Maintenance work is more irregular, and its problems are quite different from the usual production problems. Despite its importance, there is some danger that maintenance work, if placed under the production organization, would be treated as a necessary evil and therefore would not receive the attention that it deserves.

The organization shown in Fig. 61 will serve to clarify the functions of the maintenance department, and will fit in with the organization which was outlined originally. Under certain conditions, it would be suitable for a large plant.

As in the case of other organizations which have been outlined, the same functions of management that are present in the large are also present in the small organization. They should be handled as adequately in the latter as in the former. The fact that they are present in a lesser degree and that in many cases a given executive must handle a number of functions, does not change the need for a proper regard for functions.

The planning and clerical section keeps the records of the maintenance department, and performs such other clerical work as may be necessary to the work of maintenance. In some instances there may

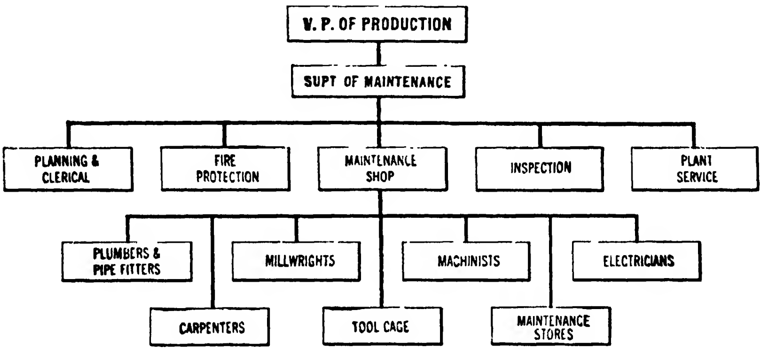



FIG. 61
THE MAINTENANCE ORGANIZATION

be one or more estimators who plan the work. In the case of major repairs which will take considerable time, the estimators look the job over, determine the nature and extent of the repairs, estimate the time required, and write up instructions and the expense order. In the case of minor repairs, the estimates can be made and instructions written without leaving the office.[1] On the basis of these estimates, the work of the department is laid out.

The fire-protection section is charged with safeguarding the plant against fire. The work involves the inspection and maintenance of fire equipment, training of the plant fire department, and similar work.

The inspection section is engaged in the inspection of equipment to anticipate repairs and completed maintenance jobs.

The plant service section is engaged in the upkeep of the plant

[1] In many cases, repairs may be so minor or of such a nature that it is not practicable to estimate the time.

and the operation of general plant service. In this section are such workers as sweepers, window-washers, elevator operators.

The maintenance shop maintains and repairs the machinery, power transmission, and other equipment. The varied nature of the work means that it must have a varied force of mechanics such as carpenters, machinists, electricians, plumbers, and millwrights. In the small plant even this degree of specialization is not possible. The maintenance department may consist of one or two general mechanics. The equipment of the maintenance shop usually consists of a number of general-purpose machine tools used by the different trades and such small tools as are not part of the personal equipment of the mechanics. A list of the duties of the maintenance shop will indicate the nature of its work and show the necessity for such a varied force. The maintenance shop must maintain in the best possible condition:

- Buildings
- Sewers
- Piping; water, air, steam and gas
- Motors
- Wiring
- Plumbing
- Shafting and power transmission equipment, including belting;
- Lighting equipment
- Installation of new machinery and equipment
- Maintenance of machinery and equipment
- Elevators
- Conveyor systems and other transportation equipment

The above statement is not intended to be a complete list of maintenance shop work.

Many materials and supplies necessary for maintenance work are to some extent peculiar to it. It is often considered not worth while to issue them in small lots directly to the maintenance mechanic, as work of accounting and storing them more than offsets any gains from a closer control. As a result, the maintenance department often has its own storeroom.

Each of the principal units in the organization is managed by a foreman or section head, who reports to the superintendent of maintenance. Because of the unusual situations which are constantly arising in connection with maintenance work, and which must be handled quickly and efficiently, the superintendent of maintenance must be a resourceful executive, having more than ordinary mechanical experience and ability.

In discussing maintenance, we have referred to the executive in charge of this function by the above title. Unfortunately, the nomenclature is not standard. Such titles as engineer of works, master mechanic, superintendent of motive power and equipment, plant superintendent, superintendent of equipment and buildings, plant engineer and many others are applied to the head of the maintenance department.

**The Functions of the Maintenance Department.** In the discussion of the maintenance organization, we have indicated, in a general way, the functions of the department. Mr. Frederick A. Waldron summarizes these functions as follows:[1]

1. Make emergency repairs.
2. Inspect machinery and equipment at such intervals as will insure detection of misadjustment, wear or impending breakdown.
3. Make such repairs or replacements as inspection shows to be necessary.
4. Keep systematic records of equipment, inspections, and repairs.
5. Keep tickler records to warn of the necessity of reinspections.
6. Suggest and assist in developing changes and improvements in design of machinery and equipment to decrease liability of breakdown and necessity of frequent adjustments or repairs.
7. Put into effect changes and improvements developed under (6) above.
8. Operate such service departments as may be assigned to the maintenance department.

Because of space limitations, discussion must be limited to the handling of emergency repairs and the work of maintenance inspection.

**Emergency Repairs.** Emergency repairs include any interruptions to production due to the failure of machinery and equipment to function properly. Such interruptions must be removed and the equipment returned to production at the earliest possible moment. As we have pointed out previously, when a machine breaks down, a steadily mounting expense is incurred until it starts to produce again.

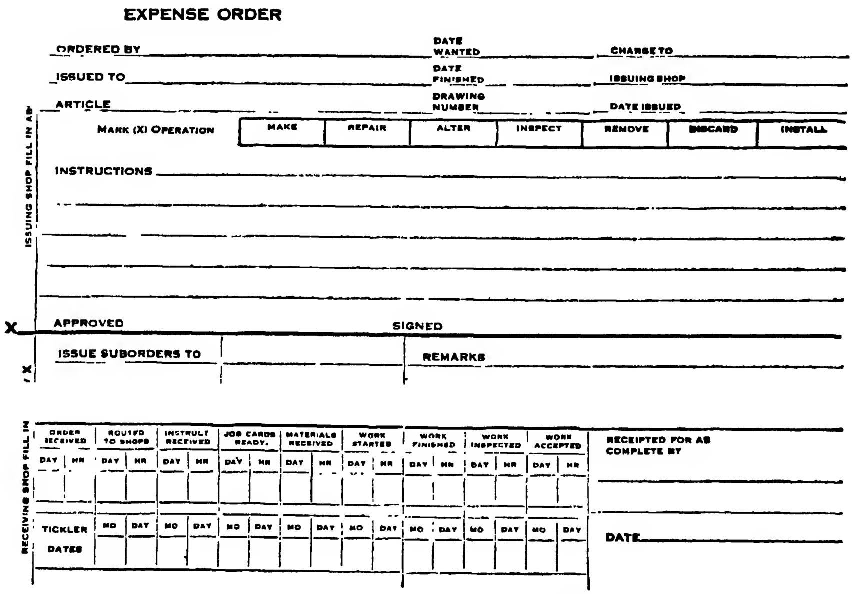
When such an interruption occurs, the department foreman usually notifies the planning office or the maintenance department office by telephone. The foreman also originates an interruption report which is sent to the planning office in order that it can make promptly any changes in plans and schedules which may be necessary. Fig. 41 shows an interruption report.

When the call is received, the interruption is noted. If it is of major importance, such as the breakdown of a large machine which will require considerable time to repair, an estimator may be sent to look over the job and decide what repairs are necessary, how they shall be made, what tools and equipment are necessary, and how long the job should take. In some plants, if the break cannot be repaired quickly, the machine is removed to the maintenance shop and repaired. A machine in good repair is immediately set up in its place and production proceeds with a minimum of delay. For a number of reasons,

[1] *Management's Handbook*, p. 1037.

such procedure is profitable only in large plants, under quantity production, which are able to make the additional capital expenditures that are necessary. In the case of minor repairs, such as a broken belt, it is not worth while to have the estimator estimate the job.

The estimator writes an expense order and instructions for making the repairs. In some cases these instructions may be written on the expense order. The order gives the necessary authority for making the repairs. The original copy is sent to the cost department and is the basis for charging the mechanic's time and the material to the



EXPENSE ORDER

ORDERED BY — DATE WANTED — CHARGE TO

ISSUED TO — DATE FINISHED — ISSUING SHOP

ARTICLE — DRAWING NUMBER — DATE ISSUED

| MARK (X) OPERATION | MAKE | REPAIR | ALTER | INSPECT | REMOVE | DISCARD | INSTALL |
|---|---|---|---|---|---|---|---|

INSTRUCTIONS

X APPROVED — SIGNED

ISSUE SUBORDERS TO — REMARKS

ISSUING SHOP FILL IN AB[OVE]

RECEIVING SHOP FILL IN

| | ORDER RECEIVED | | ROUTED TO SHOPS | | INSTRUCT RECEIVED | | JOB CARDS READY | | MATERIALS RECEIVED | | WORK STARTED | | WORK FINISHED | | WORK INSPECTED | | WORK ACCEPTED | | RECEIPTED FOR AS COMPLETE BY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DAY | HR | DAY | HR | DAY | HR | DAY | HR | DAY | HR | DAY | HR | DAY | HR | DAY | HR | DAY | HR | |
| TICKLER DATES | MO | DAY | MO | DAY | MO | DAY | MO | DAY | MO | DAY | MO | DAY | MO | DAY | MO | DAY | MO | DAY | DATE |

*Courtesy—The Winchester Repeating Arms Co.*

FIG. 62

AN EXPENSE ORDER

proper expense account. In many cases the cost department does not receive a copy of the expense order inasmuch as these items will be charged to some standing expense order. A second copy may be given to the maintenance shop foreman as notice of the interruption, and what must be done. It should be returned to the maintenance office when the job is completed as notification of that fact. A third copy may be kept in the maintenance office for entry on any work control or other records which are kept. It is forwarded to the chief preparation clerk when the interference is removed.

As soon after receipt of his copy of the expense order as possible, the maintenance shop foreman sends a mechanic to the department

to repair the break. The man's time and any material which is used are charged to the order number on the expense order. For many kinds of routine maintenance work, such as belt lacing, it is not practicable to issue an expense order for each job. The man's time is charged to a standing expense order by his time ticket.

It is not desirable to have expense orders issued by minor executives at will. Their use may be checked by requiring that expense orders for repairs that are estimated to cost more than a given figure must have the approval of the maintenance superintendent. Fig. 62 shows an expense order.

In making repairs, something more than getting the machine back into production at the earliest possible moment must be considered. In looking the job over, the estimator should endeavor to determine not only what repairs are necessary, but also what can be done to prevent a recurrence of the break. Any suggestions for preventing a recurrence should be presented to the maintenance superintendent, and, if approved, should be placed on the department's program to be handled whenever the maintenance work gets slack. Mr. Waldron points out that the measure of the efficiency of the maintenance department is the freedom of the plant from emergency repairs.

**Maintenance Inspection.** The reduction in the number of emergency repairs means a great saving to the plant. There are fewer interferences to production, the repairs which must be made to keep the machinery and equipment in first-class condition are usually less extensive than those which must be made as the result of an actual breakdown, and these repairs can be made during noon hours, Saturday afternoons and Sundays, and at other times when the plant is not working.

In order to reduce the number of emergency repairs it is necessary to have a force of maintenance inspectors and the periodic inspection of all machinery and equipment. Some such procedure as the following may be used. A maintenance inspection order is made out for each item to be inspected. A schedule is made out for each inspector. The items to be inspected are distributed to the inspectors to make up routes which will involve the least amount of travel between jobs. In some cases, there may be minor repairs or adjustments which can be made by the inspectors at the machines. This work is indicated on the inspection order. No expense order is made out for it, as such work is charged to a standing expense order for maintenance inspection.

The information which appears on the maintenance inspection order is as follows:

(1) Department.
(2) Machine name.
(3) Machine number.

(4) Location.
(5) Date of inspection.
(6) Nature of inspection.
(7) Inspector's statement of condition and needed repairs.
(8) Action taken.
(9) Date set for next inspection.

Fig. 63 shows a maintenance inspection order.

As the inspector completes the work called for under (6), he states his findings under (7) and specifies in detail the nature of any repairs or adjustments which should be made.

INSPECTION ORDER

Date ________ Department

Mach. Name ____________________ Mach. No.

Inspector ____________________ Location ________

Instructions: ____________________

Inspector's Report:

Action

Next Inspection:

Approved,_

FIG. 63
A MAINTENANCE INSPECTION ORDER

As these orders are returned to the maintenance office, they are analyzed to determine the extent of any work which must be done, expense orders are written, and the work is placed on the maintenance schedule. Usually such maintenance work is not urgent and can be fitted into the schedule when most convenient. The expense order number, the date when the work is scheduled to be done, and the date when it is completed are entered under (8). The inspection order may be filed with the expense order until the work has been

completed. Afterward, a record of the inspection and the repairs is made on a maintenance record, Fig. 64. Finally the inspection order is placed on a tickler file under the date when the next inspection is to be made. It automatically comes to the attention of the maintenance office on this date, in this manner assuring regular and periodic inspection.

**MAINTENANCE RECORD**

Mach. Name. ______________________ Mach. No. ________

Description ______________________________________

Department. ______________________ Location ________

Purchase Price ______________ Depreciation Rate ________

Equipment _______________________________________

| Date | Repairs | Amt | Date | Repairs | Amt |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

FIG. 64
A MAINTENANCE RECORD

The information which usually appears on the maintenance record is as follows:

(1) Machine name and number.
(2) Description of machine.
(3) Machine symbol.
(4) Location.
(5) Any special tools and attachments.
(6) Record of inspections and repairs.
 (a) Date.
 (b) Action taken.
 (c) Remarks.

It may be kept in loose-leaf form, the record for each machine or piece of equipment being kept on a separate page. Many maintenance authorities feel that a detailed record of repairs is unnecessary, as the

foreman's knowledge of the performance of the machine is sufficient to indicate when it should be scrapped.

**Standards for Maintenance Work.** Because of the irregular nature of maintenance work, it is difficult to set production standards except for such routine work as window-washing, sweeping, and similar jobs. There are instances where time studies have been made and production standards set for such work. For the major part of maintenance work, if it is desired to have wage payment in proportion to production, the standard must be based on the estimate of the inspector or an estimator from the maintenance office. Furthermore, bonus earnings should be based on the average efficiency for the month, inasmuch as the maintenance mechanic may encounter difficulties in the job which could not well be foreseen by the estimator.

Because of these difficulties, it is not possible to hold the mechanic strictly to the instruction on the expense order. He must be permitted to exercise some discretion as to the best method of making repairs in the light of conditions as they actually disclose themselves.

# CHAPTER XV

## THE CONTROL OF MATERIAL—THE NATURE OF THE FIELD

**The Importance of Material Control.** From the manufacturer's standpoint, production consists of the proper application of men and machines to material for the production of economic goods. It is apparent that for most plants the proper control of materials is one of the most important problems of management.

The importance of material control and the extent to which it has been developed will vary between plants, according to the character of the product, the manufacturing problems involved, and the degree of managerial ability which is present. In a plant which is operating under conventional methods of management, it is probable that the importance of the material problem will not be realized entirely. Material control will be lax correspondingly. In plants which operate with modern management methods, usually methods for material control have been developed to a high state of efficiency.

Where material problems are handled in a lax manner, there is always the danger that serious losses will creep in, many of which can easily escape detection if the proper control machinery is not present. Materials may not be purchased and delivered to the plant in time to avoid costly interferences to production. Stocks of materials or supplies may become exhausted, resulting in higher costs for rush shipments and the cost of delayed production. If we have no proper material control, inventories may become unduly expanded as a result of unduly large purchases or too many separate items carried in stores. Many of the failures which occurred during the depression in 1920 and 1921 resulted directly from over-expanded inventories of both raw and worked materials. Losses may be caused by variations in the quality of materials purchased and received into the plant. Such variations may affect adversely the cost of production and the satisfaction of our customers with the product. Failure to salvage properly waste and scrap materials from industrial processes may mean a considerable leakage of profits into the scrap pile. Where there is no good system of material control, the books of the company usually are not closed more often than annually or semiannually, because of the difficulty of taking a physical inventory of raw, worked, and finished materials. The lack of current information concerning the condition of the

company may impair the effectiveness of managerial control. In the handling, storage, and movement of materials there are many opportunities for wastes to occur. In these and many other ways, the success of the company may be affected considerably by the quality of its material-control methods.

Many concerns install expensive accounting and cost systems, watching expenditures carefully. Safes or vaults are provided for the cash on hand, for which an accounting to the last penny must be made. On the other hand, stocks of materials, costing large sums, are left with the minimum of protection. Good control of these inventories may be almost nonexistent. For some reason, cash on hand seems more apparent and real than far greater amounts invested in materials. It is not unusual for large concerns to have inventories representing an investment of a million dollars or more. In most cases, such concerns realize the value of material control and make proper provision for it. Yet the inventories of smaller concerns, in proportion, are equally as important. In some industries, the material cost is sixty or seventy per cent of the total cost of production.

**The Functions of Material Control.** The functions of material control are to supply the material that is wanted, when it is wanted, at the point where it is needed, in the proper quantities and at the most economical cost with regard to the requisite quality. It must so control the flow of materials into the plant that production will be supplied adequately without creating inventories which are unnecessarily large. It must supply information to the planning and cost departments which will assist them in the performance of their functions. It must see that all inventories are properly utilized.

**The General Classification of Stores.** Material control includes the control of all materials and supplies not actively in use. Therefore it includes:

(1) *Raw Stores.* In this classification are included raw material. They may be procured either by purchase or by manufacture. The greater part of such stores are used directly or indirectly in production.

(2) *Miscellaneous Stores.* This classification includes supplies used directly or indirectly in manufacturing.

(3) *Worked Material.* This term usually is applied to material to which men and machines have been applied but which has not been completely processed into finished parts or products. Sometimes it is necessary to split an order of parts and put a portion of the order into stores. In such cases an item of worked materials should appear on the stores books.

(4) *Component Parts.* This term usually applies to parts which have been completely processed for assembly into the finished product.

All finished parts should be recorded on the stores ledgers and placed in stores as soon as they are completed. In many cases this may not be done physically but by means of a paper transaction. Actually the parts may be delivered directly to the assembly floor.

(5) *Finished Product.* This term refers to product which has been finished for sale, except salvage material. Here again the finished product may not be put into stores physically, but may be delivered directly to the shipping floor. However, it should be put through stores on a paper transaction for purposes of inventory control and accounting.

(6) *Unclassified Stores.* In this group are all materials which are not carried regularly in stores or which are not classified elsewhere.

(7) *Salvage Stores* include all scrap and waste materials received by the salvage organization, and all salvage products reclaimed from such materials for sale or replacement in general stores. In some cases it may include the manufacture of certain by-products.

**The Work of Material Control.** The work of material control can be divided roughly into six phases—(1) procurement, (2) storage, (3) transportation (4) salvage, (5) the development of standards, and (6) control.

By procurement is meant the work of securing the materials and supplies for production and the conduct of the business. Procurement may be effected by manufacture or by purchase. It is the business of the plant to manufacture finished product. Inventories of finished product and the parts of which it is composed are normally procured by manufacture. In some instances, certain materials and supplies also may be manufactured in the plant. In the average plant most of the raw materials and supplies are procured by purchase. In some instances certain parts which cannot be produced to advantage in the plant also are procured in this manner. In the first case, the materials organization is concerned with the study of materials, markets, and vendors, the making of purchase contracts, and the routine of purchasing. In the second case, it is concerned with production and production control, although not directly responsible for them.

In connection with the work of storage, it is concerned with the provision of proper places for the storing and piling of material, the selection of handling equipment, the handling and control of stock, the organization and location of storerooms and similar problems. In many respects the work of receiving and inspecting purchased materials is closely related to the work of storage.

The transportation of materials results from a transfer of responsibility for their proper handling and safekeeping. There are two principal phases of this work—the internal transportation of materials and

the shipping of finished product from the plant. The first has to do with the movement of materials within the plant. The second case has to do with the movement of finished product to the consumer on the order of the sales department.

In the work of control, the materials division is concerned with the operation of the stores ledgers, the checking and controlling of inventories, the determination of minimum ordering points and maximum ordering quantities, the symbolization of materials, the furnishing of cost and planning information, and problems of a similar nature.

As previously stated, the work of salvage has to do with the handling, processing, and disposing of waste and scrap materials.

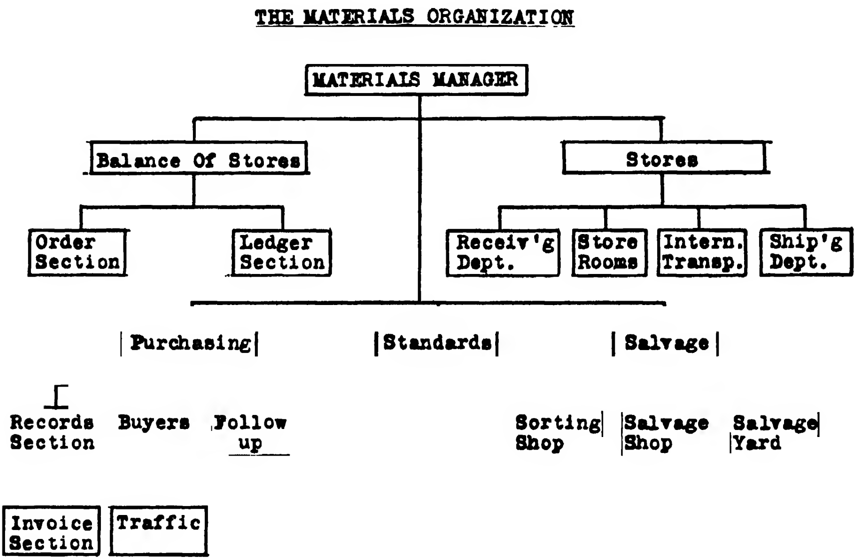



FIG. 65
THE MATERIALS ORGANIZATION

In large materials organizations, there may be a section responsible for the development of material-control methods and standards. If there is a methods manager, as suggested in Chapter VI, they properly may be developed under his direction, subject possibly, to the general supervision of a materials committee.[1]

**The Organization for Material Control.** In the organization set up in Chapter VI, the work of material control is handled by the materials division. In that chapter a discussion of the general functions performed by the various departments of the division was given. The organization of the materials division is shown in Fig. 65. This

[1] See Chapter V.

organization is not intended to weight the importance of the various phases of material control, but rather to emphasize its principal functions. Furthermore, the relationships of the various organization units administering material control functions will vary with every concern, depending on the nature of the management problems.

## CHAPTER XVI

## THE CONTROL OF MATERIAL—PURCHASING

**The Work of Purchasing.** The functions of the purchasing department are to procure by purchase what is wanted, when it is wanted, in the proper quantities and at the lowest price consistent with requisite quality. The determination of what is wanted involves the kind of material that is required and the desired quality. In the modern purchasing organization, these two factors are determined in most cases by means of material specifications. With some exceptions, such as office materials, these specifications are written by the engineering department for all materials regularly purchased. Copies are on file in the purchasing department. The quantity to be purchased is governed in most plants by the production program, and purchase requisitions from the balance of stores department and possibly certain executives authorized to issue them. In some plants it is a matter of the purchasing agent's judgment, guided possibly by a materials committee. One of the principal duties of the purchasing department is to procure material in time to meet the needs of the production organization. In securing deliveries, the purchasing department may be guided by the production program, the dates when specific orders are scheduled to start, or the normal usage of the stores department, depending on the methods in use and the nature of the purchase requisition. In purchasing, the lowest quotation is not always the cheapest. The quality of the material offered may not be satisfactory. Its properties may be such that it is not easily worked. Delivery dates may not be satisfactory, or other reasons may make it advisable to accept a bid which is not the lowest.

**The Purchasing Organization.** The purchasing organization is under the supervision of a purchasing agent in most cases. In the organization on page 228 he reports to a materials manager. The position of the purchasing agent in the organization depends to some extent on the nature of the organization and its purchasing problems. In organizations which use large quantities of speculative materials, such as textile plants, the purchasing agent is an executive of great importance. In many cases he has practically free rein because of the wide fluctuations which often occur in the basic raw materials, cotton and wool, and the necessity for procuring a supply of raw material at a favorable price. In extreme cases the purchasing function, in so far as the pro-

curement of speculative materials is concerned, may be handled personally by the president or some other managing executive of the company.[1] However, such practices are not advisable unless the characteristic price movements of the major materials, the nature of available supplies, and the customs of the industry make them necessary and the managing executive has the requisite knowledge and experience. For the average plant that uses materials not subject to violent price movements, of which there is normally an adequate supply, it is better to control the purchase of materials through the operation of the balance of stores ledgers. It is natural for the purchasing agent to have a bargain-hunting tendency. Unless this tendency is properly controlled, it may result in the building up of too large inventories and the stocking of goods which shortly become obsolete as far as the needs of the plant are concerned, or which cannot be used advantageously. A cheap price may prove to be very expensive. Such results are probable, particularly if the purchasing agent is not sufficiently in touch with the present and future plans and needs of the engineering and production organizations. Such instances can be prevented by a proper control of purchasing, without inhibiting the exercise of initiative by the purchasing agent.

Between the speculative purchasing agent who operates almost entirely on his own initiative, and the purchasing agent of the small plant who is little more than a clerk, buying what the shop needs on the order of authorized executives, there are all degrees of executive importance. However, in a plant of any size, in which the purchasing function has been properly developed, the purchasing agent is an important major executive. He is an expert who knows markets and materials. He must have a practical knowledge of economics, particularly with regard to the characteristics of price movements, in order that he may advise properly the higher executives of the plant regarding matters of purchase policy. He must be an executive, competent to supervise the work of purchasing.

In the larger organizations there is usually an assistant purchasing agent who relieves the purchasing agent of the routine work of supervising the department. There are buyers who do the actual work of securing bids on orders, interviewing salesmen, placing purchase orders. declining quotations and similar work, subject to the approval of the purchasing agent or his assistant. There are record clerks who keep the files of material specifications, statistical data, vender's files, quotation files, purchase-order files, catalogue files, and other records used by the purchasing department in its work. There are follow-up clerks

[1] In some instances, the procurement of such materials is so important that separate organizations for speculative and routine purchasing are maintained.

who schedule and follow up shipments, after the purchase order has been placed and accepted, to insure that they will be received on the promised date. There may be a traffic section which routes shipments, follows up shipments delayed in transit, checks freight bills, and takes up claims with the railroads.[1] There are invoice clerks who check the invoices against the purchase orders and reports of the receiving department, and certify to the purchasing agent the correctness of invoices for approval for payment.

Such an organization may seem unduly complex. It was not long ago that the foreman or superintendent of a department or shop purchased the materials and supplies that he needed for his work. Instances of such methods can be found occasionally in the smaller plants today. However, they are not found in the better-managed plants having a large volume of production. The purchasing department of a good-sized plant purchases in the course of a year many thousands of widely differing articles. They range from coal, steel, oil, machinery, and similar large and expensive items to inexpensive office supplies. Different departments require materials which serve similar purposes. It is obvious that unless the work of purchasing is centralized in the hands of a trained staff great losses may occur which will more than offset anything that could be saved by economizing unduly on the purchasing department. The trained purchasing agent is familiar with the product and its requirements. He is further aided by material specifications which have been accurately and thoroughly prepared. He is in a position to view the purchasing problems of the plant as a whole, and as a result to serve it with the greatest economy. He knows markets, business, and price cycles which the average department head does not. He is familiar with the various sources of supply and knows the character, capacity, and ability of different vendors. He understands the advantages and characteristics of different kinds of contracts, discounts, and purchase technique. In almost any plant he can render service which will return large savings to the company.

**Purchasing Methods.** There are a number of methods of purchasing. The three which probably are the most widely used are (1) purchasing under control of the balance of stores department; (2) speculative purchasing; and (3) contract purchasing. As stated previously, the purchasing of routine items under the control of the balance of stores department is probably the safest and most economical method for the average plant. Under this method, material is purchased on the authority of purchase requisitions received from the balance of stores

[1] However, the work of the traffic section also bears an important relation to the work of the sales department. Accordingly, the traffic supervisor may report to the sales manager in some cases. In others, the traffic department may be independent, probably under the jurisdiction of the vice-president in charge of production.

department. Usually there appears on the stores ledger sheet, for each item carried in stores, a minimum ordering point or quantity. When the available stock of a particular item falls to this quantity, a purchase requisition is written by the order clerk of the balance of stores department and sent to the purchasing department. This point depends largely on the rate of consumption and must be set to allow the purchasing department sufficient time in which to procure a new supply of the material. In a great many plants, an arbitrary figure which approximates three months' supply is used for most items. The quantity which is ordered also depends largely on the rate of consumption and is determined with a view to obtaining the highest practicable turnover of inventories and the working capital invested in them. It also depends on the extent of control of sources of supply. It is said that one of the largest manufacturers in the country, who has unusually good command of his sources of supply, operates on less than a week's supply of raw materials.

The purchase requisition, an example of which is shown in Fig. 66, is merely a request for a purchase order. When the purchase requisition is received by the purchasing department, the routine of purchasing, resulting finally in the placing of a purchase order, is initiated. While this method controls any tendency of the purchasing agent to speculate in raw materials, it has the disadvantage that the company probably will be less quick to take advantage of changes in price trends, although the purchasing agent is in a position to, and should advise his superiors regarding impending price changes. However, the present tendency seems to be to forego speculative profits in materials and to hold inventories to a minimum.

If the purchasing department engages in speculative purchasing, the time of buying and the quantities bought are left largely to the discretion of the purchasing agent, although his activities may be supervised by a materials committee. In many cases he is guided only by a production program and his knowledge of the business. This method is more common among concerns which purchase large quantities of speculative materials. To use it successfully, the purchasing agent must be a shrewd, keen student of business and the commodities which he buys. To determine when a downward price movement has run its course and an upward movement is about to begin is no easy matter. However, in the modern organization he may be aided in this determination by information furnished by a highly organized statistical department.

The term "purchasing on contract" refers to the use of contracts covering a supply of materials for a considerable period in advance of manufacturing. Strictly speaking, all materials are purchased on

COPY 1 — PURCHASE REQUISITION — № 34596

TO PURCHASING DIVISION:

DATE ________

PLEASE ORDER THE FOLLOWING, TO BE HERE ________ TO BE USED FOR ________

APPROVED — PLAN. SECT. PURCH. DIV.

| STORES SYMBOL AND LOCATION | SPECIFICATION NUMBER | DESCRIPTION | QUANTITY | UNIT |
|---|---|---|---|---|
| | | | | |

ORDERED BY ________

MAXIMUM ________ MINIMUM ________

QUANTITY UNAPPORTIONED ________

WILL LAST ________

SCHED. SEC. BAL. OF STORES

APPROVED

BALANCE OF STORES

APPROVED — PREP. SEC. PURCH. DIV.

| REMARKS | | BIDDER | SOURCE OF QUOTATION | LIST PRICE | TRADE DISCOUNTS | NET PRICE | F. O. B. POINT | PRICE N. H. | TERMS | SHIPMENT PROMISED | REL. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | | | | | | | | |
| | 2 | | | | | | | | | | |
| | 3 | | | | | | | | | | |
| | 4 | | | | | | | | | | |
| | 5 | | | | | | | | | | |
| | 6 | | | | | | | | | | |
| | 7 | | | | | | | | | | |
| | 8 | | | | | | | | | | |
| | 9 | | | | | | | | | | |

REMARKS—ALL QUOTATIONS MUST BE RECEIVED BY

№ 34596

REQUISITIONER WAS NOTIFIED THAT MATERIAL CANNOT BE DELIVERED UNTIL ________ BY ________ SCHED. SECT.

QUOTATION RECORD POSTED BY ________

SHIPPER MUST SHIP VIA ________ ON ________ SCHEDULED BY ________

TO ARRIVE IN NEW HAVEN, CONN., ON ________ SCHED. SEC. PURCH. DIV.

ORDER PLACED WITH ________ ON ________ ORDER NO. ________

REASON ________ SIGNED ________ PROD. SEC. PURCH. DIV.

*Courtesy—Winchester Repeating Arms Co.*

FIG. 66

A PURCHASE REQUISITION

some form of contract. To illustrate, contracts may be made covering the year's requirements for a major item of material. Consignments of the material are shipped during the year on instructions from the purchasing department. By this method an adequate supply of materials to meet the needs of production is assured.

**Material Specifications.** The material specification is a detailed description of the chemical and physical characteristics of a given item of material. It includes such information as the chemical and physical properties of the material, its form, finish, the manner in which it should be packed for shipment, any tests which it should pass to determine the extent to which it meets the specifications, permitted substitutes, and similar information. The specifications are prepared by the technical experts of the plant or others who are competent. The essential points are incorporated in the purchase order, a copy of which goes to the receiving department as well as to the vendor. They are the basis of the work of receiving inspection as well as of the purchase contract.

**Purchasing Department Files.** In addition to the files of material specifications, there are many other files of information, some or all of which will be found in the well-organized purchasing department. The material file accumulates information regarding each item or class of material which is purchased regularly. A card is maintained for each individual item. The nature of the information on this card is indicated in Fig. 67. In some cases the form may be printed on a filing pocket in which information relating to methods of manufacturing the material, new substitutes which have been developed, or other information concerning the material which is of interest to the purchasing agent may be filed. The purpose of the file is to bring together in usable form, all general information relating to each item of material and its sources of supply. In many instances, this form can be combined to advantage with the quotation record.

The quotation file furnishes a record of all purchases of each item of purchased material. A card such as that shown in Fig. 68 is made out for each item. The purpose of the quotation file is to furnish a continuous record of prices paid or quotations received for a given item of material over a period of years. In the case of some materials, such as copper, rubber, pig iron, and cotton, prices are quoted regularly in trade publications or other mediums. The buyer follows these quotations daily and is thoroughly informed regarding their price trends. Every concern purchases a great many materials for which there are no well-organized markets from which quotations can be obtained regularly. In the case of such items, the quotation file furnishes valuable information which will aid the buyer in determining

what is a fair price. Even in purchasing raw materials, enjoying broad, well-established markets, the quotation file may be very useful.

**MATERIAL RECORD**

Material Name ____________________

Specification Number ____________ Symbol ________

Description ____________________

| Vendor | Address | Capac. | Del. Time Frt. | Exp. | Remarks |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

FIG. 67
A MATERIAL RECORD

The vendor's file furnishes a record of the performance of each vendor from whom we have procured material. A card such as is

**QUOTATION RECORD**

Material Name ____________________

Specification No. ____________ Symbol ________

Description ____________________

| Date | P.O. No. | Quant. Purch. | List Price | Disc | Net Price | Frt. | Total Cost | Unit Cost | Vendor | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

FIG. 68
A QUOTATION RECORD

shown in Fig. 69 is made out for each individual vendor. If the vendor failed to meet his promised shipping date, did not ship the

goods in accordance with the directions in the purchase order, refused to make reasonable adjustments, or for any other reason failed to give satisfactory service, it is entered on his record under remarks. The vendor's record is not intended to take the place of the usual sources of information regarding the reliability of the vendor and his ability to fulfill his contract, but rather to supplement them.

The purchasing department of every concern is constantly receiving catalogues and circulars relating to materials for which the company normally is in the market. These catalogues contain much information of value to the buyer and sometimes indicate sources of supply which have not been used previously. Unless they are properly con-

VENDOR'S RECORD

Vendor's Name ____________ Address ____________

Products ____________

Capacity ____________ Credit Rating ____________ Our Rating ______

| DATE | P.O. NO. | Material | Symb. | Quant. | Remarks |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

FIG. 69
A VENDOR'S RECORD

trolled, they are soon lost or they are not readily available. Most well-organized purchasing departments regularly index and file the catalogues for which they have any use, and place them under the control of a file clerk who is responsible for them.

In addition to the foregoing, all completed purchase orders are filed. Usually the essential information relating to the fulfillment of the contract is indorsed on the order. It is then filed according to order number.

**Other Sources of Information.** In addition to the information which the purchasing agent can obtain from these records, he must keep himself thoroughly informed regarding the condition of markets and the trend of business. Regardless of the nature of the purchase control which is used, he can save considerable sums of money for the com-

pany by advising his superiors regarding impending price changes of which the company can take advantage in the purchase of materials. Today, there are a number of nationally known concerns whose sole business is to sell economic information and advice relating to the trend of business. Every great industry has its trade journals, many of which carry current quotations on its principal materials in addition to other trade information of interest to the buyer. The purchasing agent must spend considerable time in studying such sources of information.

In organizations which do not have some central statistical department, the purchasing department often keeps its own statistical records. Business and price information is recorded and represented graphically. The price trends of the principal materials used by the plant and the actual results of purchasing are plotted. A graph of this kind is shown in Fig. 70. Without such information, it may be difficult for the purchasing agent to form an intelligent opinion of probable movements. While the movements of production and prices in individual industries tend to conform to the movements of the general business cycle, actually they may move considerably ahead or behind it, due to conditions which are peculiar to the industry.

**Types of Contracts.** When the purchase requisition has been received by the purchasing department and the foregoing sources of information regarding markets and sources of supply have been studied, the type and form of contract to be used must be determined. The two most common types of contracts are (1) the individual contract and (2) the blanket contract.

The individual contract or purchase order covers a particular shipment of material. Such questions as price, time, and conditions of delivery and the other factors which affect the making of the purchase contract are settled at the time the order is placed and are incorporated in the purchase order. They apply only to the shipment under consideration.

The blanket contract covers the delivery of a supply of material, usually over an extended period of time. It is used when it is desirable to cover the material requirements of the plant for a given item considerably in advance of manufacturing. It insures that the plant will have an adequate supply of material regardless of the condition of supplies in the open market. To illustrate, a certain company may be a large consumer of pig iron. The price of pig iron has been declining steadily for a number of months. As a result of his study of general business conditions and conditions in the iron and steel industry, the purchasing agent has concluded that the price of pig iron will not go much lower and that shortly it will start on an upward movement

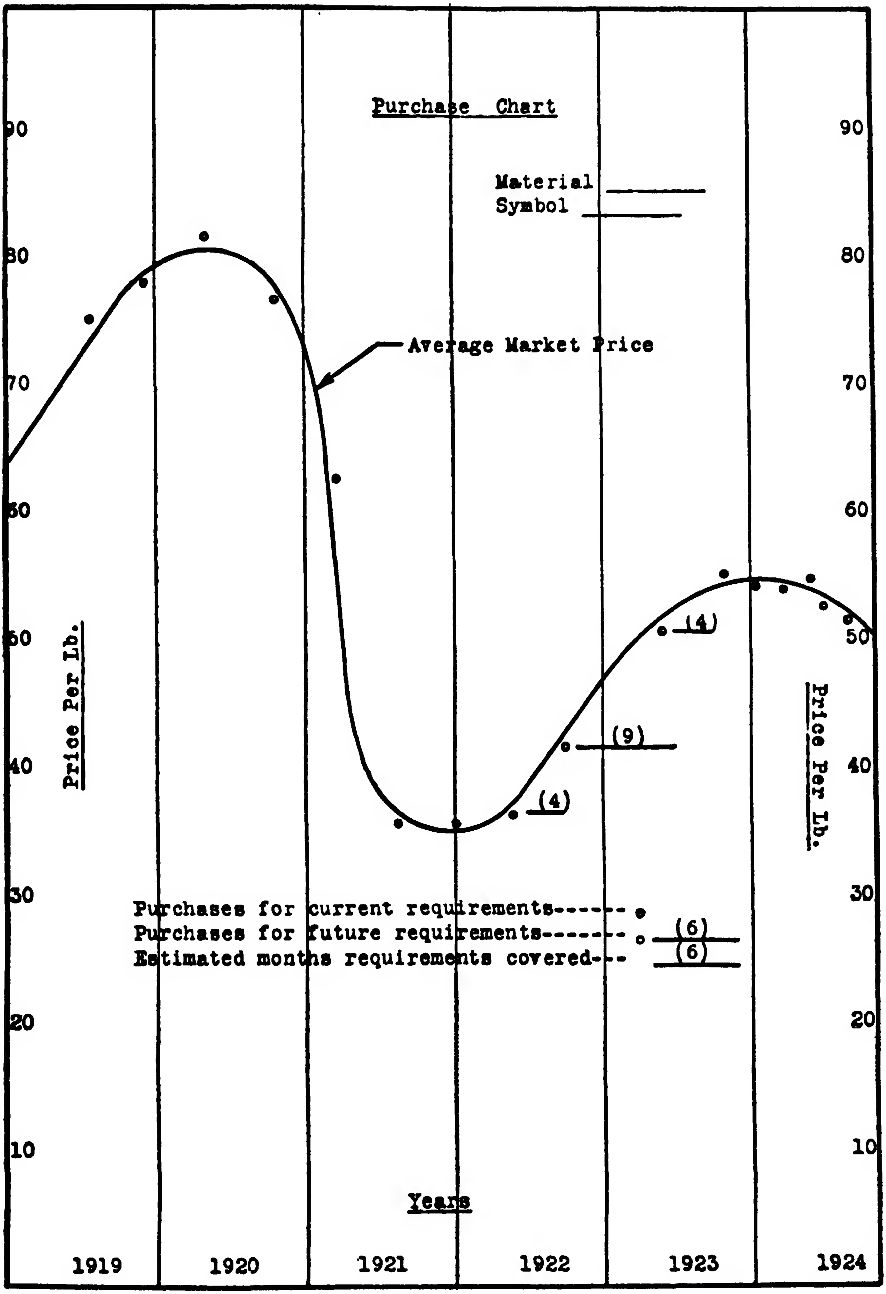



FIG. 70
A Price Purchase Chart

that probably will continue over an extended period in the future. He recommends to the materials committee that a policy of forward buying of pig iron be authorized. If his recommendation is approved, the purchasing agent probably will proceed to place contracts for a quantity of pig iron sufficient to meet the needs of the plant for the coming manufacturing period, or a longer period if such action is authorized. In this case, probably a flat price would be established for the contract. Shipments would be made when released by sub-orders issued under the contract. In this manner, the purchasing agent has secured for the plant a sufficient supply of material in advance of increasing business activity at a price which is favorable.

**Price Clauses in Contracts.** Contracts differ with regard to their price clauses. The most familiar of these are (1) the flat price contract, (2) the cost-plus contract, (3) market at time of shipment, and (4) contracts with penalty clauses.

In the flat-price contract, the vendor and the vendee agree on a price which applies to the whole contract. If the price of the item goes up, the vendee profits thereby. If the price drops, he suffers.

With the cost-plus contract, the buyer agrees to purchase at the cost of producing the item plus an agreed percentage of profit. The buyer has the right to inspect the books of the seller to verify the cost statements. This type of contract was common during the war and post-war periods when price conditions were very unstable. Its use was particularly prevalent in the building industry because the prices of building materials and labor were advancing so rapidly that it was impossible to make a cost estimate which could be relied on for any great length of time. On the surface the arrangement appears to be perfectly fair. Usually it leads to abuses. It gives an incentive to the producer to increase rather than reduce costs. There are so many ways in which costs can be increased without any such intent appearing in the cost records, that the buyer is likely to suffer unless the seller is more than ordinarily honest. For this reason, any considerable use of this type of contract is found only during a sellers' market that is unusually pronounced.

The purchase contract may read "market at time of shipment." This method of price determination is often used in connection with blanket contracts. It means that shipments of the quantity ordered are released by sub-orders under the blanket contract, the price at which each shipment will be billed to the company to be determined at the time of shipment by current quotations from some agreed source. This arrangement insures that the plant will have an adequate supply of material as it needs it. It precludes the possibility of a speculative loss due to falling prices, except as the result of competition

from other manufacturers who have bought or sold successfully on the market.

The use of penalty clauses in purchase contracts usually is intended to insure delivery as promised or quality within the limits demanded by the material specifications. In some industries, a serious problem with which the purchasing department has to contend is the delay of shipments either in transit or as the result of the failure of the vendor to meet his promised shipping date. In many purchasing organizations there is a follow-up clerk whose principal work is following up delayed orders. A delayed shipment often will result in costly delays to production in the shop. To avoid such delays, a penalty clause may be included in the contract which will permit the purchaser to make certain graduated deductions from the invoice, depending on the length of time that the shipment is delayed beyond the agreed delivery date. In other cases, failure to meet the promised date gives the purchaser the right to cancel the contract. In addition, there are instances where penalty clauses have been included which permit the purchaser to make deductions from the invoice, depending on the extent to which the shipment fails to meet the standard of quality agreed upon in the purchase contract.

**The Request for Bids.** After such questions as prices, requirements, sources of supply, and contracts have been considered, requests for bids may be sent to certain vendors. Often the form of the request is similar to that of the purchase order. It insures that the information on which bids are to be based will go to all vendors in exactly the same form, and furthermore that it will be in approximately the same form in which it will appear later in the purchase order.

Requests for bids are not sent out for all purchases. When the plant's demand for certain material is very urgent, a purchase order may be made out and sent immediately to some vendor in whom the purchasing agent has confidence.

**Quotations.** In selecting bids, the nature of the quotations must be considered and all must be reduced to a comparable basis. Sometimes the buyer must purchase an advertised article whose price is maintained. While a direct reduction from the quoted price may not be possible, in some instances it may be possible to induce the vendor to prepay the freight which reduces the cost of the item. Occasionally, if the buyer's business is sufficiently tempting, the vendor may agree to bill at his quoted price, with the understanding that the buyer will be allowed a rebate. The vendor gets the business, technically without having reduced his quoted price. While there may be some question regarding the ethics of the practice, it is the business of the buyer to get the best price that he can, with due regard for delivery and

## The Procter & Gamble Co.

CINCINNATI, OHIO

Date............................................

# INQUIRY

YOUR QUOTATION MUST BE RETURNED ON THIS INQUIRY BLANK

Please quote your lowest price on the material listed below; we reserving the right to accept all or any part of this bid. Please price each item separately.

Quotations must be in our hands by ...... .......................19...... ..to receive consideration.

GENERAL BUYING DEPARTMENT

| REQ. No. | QUANTITY | DESCRIPTION | LIST | DISCOUNT | NET PRICE | TO BE SHIPPED FROM |
|---|---|---|---|---|---|---|
| | | INSERT PRICES AND RETURN | | | | |

This is not an Order

Date...... ...............................19......

We agree to furnish any or all of the above items in accordance with prices and items herein quoted.

DELIVERED F. O. B. CARS TERMS ..........

SHIPPING DATE .............................. APPROXIMATE SHIPPING WEIGHT .............. LBS.

Signed ......................................

Per.......... SIGNATURE OF BIDDER

*Courtesy—The Procter & Gamble Co.*

FIG. 71

A Request for a Bid

quality. Often the buyer is quoted a list price less certain trade discounts. For instance, he may be quoted list price less 10-10-5. This means that from the list or catalogue price the purchaser may deduct a discount of 10 per cent, from the remainder another discount of 10 per cent, and from the final remainder a discount of 5 per cent. One reason for such quotations is that it reduces the necessity for revising the catalogue whenever any considerable fluctuation in market prices occurs. If prices rise, a new discount list can be issued in which the discounts are reduced. In the case of vendees whose purchase volume warrants it, these discounts may be adjusted sufficiently to get their business.

In addition, most concerns offer a discount for prompt payment of bills. The usual discount is 2 per cent for payment within ten days.

**The Purchase Order.** When the quotation has been selected which appears to the buyer to be the most favorable in view of the terms of delivery, quality, and price offered, the buyer writes a purchase order which is forwarded to the vendor after receiving the approval of the purchasing agent. Fig. 72 is an example of a purchase order. It does not become a contract until it has been formally acknowledged and accepted by the vendor. Some purchasing departments use a special acceptance form which is attached to the purchase order. Upon receipt of the order, the vendor fills out the acceptance form and returns it to the purchasing department. Usually a number of copies of the purchase order are written and distributed to various interested departments, such as accounting, receiving, the follow-up section of the purchasing department, the balance of stores department or others depending on the purchase routine.

The nature of the information found on the purchase order is indicated below.

(1) Name of goods.
(2) Quantity desired.
(3) Specifications.
(4) Terms.
(5) Delivery.
 (a) Receiving point.
 (b) Shipping directions.
 (c) Directions for marking.
 (d) Reservation of right to cancel order in case of nondelivery as specified.
(6) Order number.
(7) Date of order.
(8) Signature of purchasing agent or other responsible officer.

**The Invoice.** When he has filled the order and has delivered the goods to the railroad company or other carrier, the vendor sends an invoice

SEIBERLING RUBBER COMPANY

PURCHASING DEPARTMENT

AKRON, OHIO

TO

VIA

DATE TO SHIP

PLEASE ENTER OUR ORDER AND SHIP TO –

PLEASE DO NOT FAIL TO ACKNOWLEDGE PROMPTLY

CONDITIONS AND INSTRUCTIONS

MATERIAL NOT FOUND IN ACCORDANCE WITH SPECIFICATIONS ABOVE WILL BE HELD SUBJEC'
WE WILL NOT RECEIVE QUANTITIES IN ACCESS OF ABOVE SPECIFICATIONS
WHEN MATERIAL IS BOUGHT F.O B. AKRON, FREIGHT MUST BE PREPAID
EACH PACKAGE SHIPPED ON THIS ORDER MUST CONTAIN A PACKING SLIP BEARING OUR ORD
NO CHARGES FOR PACKING OR DRAYAGE ALLOWED.

SEIBERLING RUBBER COMPANY

SEIBERLING RUBBER COMPANY–PURCHASING DEPARTMENT

AKRON, OHIO ______________________192__

WE BEG TO ACKNOWLEDGE RECEIPT OF YOUR ORDER No. 9748 D

SHIPMENT WILL BE MADE IN ACCORDANCE WITH CONDITIONS AS STATED ABOVE IN ORDER.

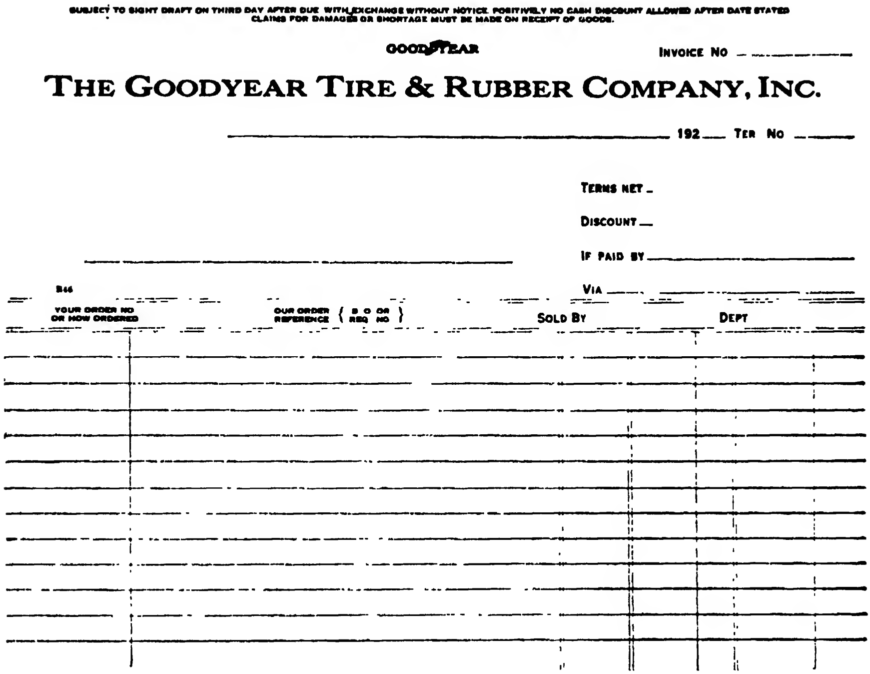
(GIVE DEFINITE DATE OF SHIPMENT) ______________________________

*Courtesy—The Seiberling Rubber Co.*

FIG. 72

A PURCHASE ORDER—ORIGINAL COPY

to the purchasing department. The invoice is merely a written notice that in accordance with the terms of the contract the vendor has rendered certain goods or services and demands payment therefor. It is the vendor's statement of the amount and kind of the goods and services rendered and the terms of the purchase contract. The nature of the information which it contains is indicated by the form shown in Fig. 73.


SUBJECT TO SIGHT DRAFT ON THIRD DAY AFTER DUE WITH EXCHANGE WITHOUT NOTICE. POSITIVELY NO CASH DISCOUNT ALLOWED AFTER DATE STATED
CLAIMS FOR DAMAGES OR SHORTAGE MUST BE MADE ON RECEIPT OF GOODS.

GOODYEAR INVOICE NO

THE GOODYEAR TIRE & RUBBER COMPANY, INC.

192 TER NO

TERMS NET

DISCOUNT

IF PAID BY

VIA

B46

YOUR ORDER NO OR HOW ORDERED | OUR ORDER REFERENCE { B O OR REQ NO } | SOLD BY | DEPT

*Courtesy—The Goodyear Tire & Rubber Co.*

FIG. 73

AN INVOICE

When the invoice is received, the invoice clerk attaches an invoice flag to it, to be used in checking the invoice. It furnishes a record of the action taken on the order. In some cases, a form may be rubber-stamped on the back of the invoice for the same purpose. The invoice is checked against the purchase order to determine its correctness and the results noted on the flag. Similarly, when the report of the receiving department is received, it is checked against the purchase order and the invoice. Other entries may be made, but these indicate sufficiently the purpose of the invoice flag.

**Discounting Bills.** An important entry on the invoice flag is the discount date. A reputation for discounting bills has a very favorable

effect on a firm's credit standing. Furthermore, a discount of 2 per cent for payment within ten days is at the rate of 36 per cent per annum. As a result, most concerns will borrow money from their banks in order to discount their bills. The invoice clerk must watch the discount date for each bill to make sure that the company does not lose the right to discount the bill because of some delay in receiving and inspecting the goods or in approving the invoice for payment. In fact, when dealing with a trusted vendor, bills often are paid and discounts taken before the inspection of goods.

INVOICE RECORD

NAME

| Date Rec'd | Duplicate Passed | Duplicate Ret'd | Orig. |
|---|---|---|---|

*Courtesy—The Van Dorn Iron Works.*

FIG. 74
AN INVOICE RECORD

**The Bill of Lading.** The bill of lading is the receipt which is given by the railroad or other carrier to the vendor for the goods which have been turned over to it for shipment. It is made out by the vendor and signed by the freight agent. One copy goes to the vendee, one to the carrier and travels with the shipment of goods, and the third is retained by the vendor.

The vendee's copy comes to the purchasing department with the invoice and is turned over to the receiving department. When the shipment is delivered, the receiving department turns its copy of the bill of lading over to the carrier and receives the goods.

Fig. 75 shows an example of a bill of lading. It is not used for goods shipped by express or parcel post, although instruments serving similar functions are used.

Uniform Domestic Straight Bill of Lading Adopted by Carriers in Official, Southern and Western Classification Territories, March 15, 1922.

**UNIFORM STRAIGHT BILL OF LADING** Shipper's No. 25920

PRESCRIBED BY THE INTERSTATE COMMERCE COMMISSION

S 1457A 5M 9-26 **ORIGINAL—NOT NEGOTIABLE** Agent's No.

........................................................................................Company

RECEIVED, subject to the classifications and tariffs in effect on the date of the receipt by the carrier of the property described in the Original Bill of Lading.

**From THE FIRESTONE TIRE & RUBBER CO., at Akron, Ohio**______________________192

the property described below, in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated below, which said company (the word company being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its own road or its own water line, otherwise to deliver to another carrier on the route to the said destination. It is mutually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all the conditions not prohibited by law, whether printed or written, herein contained, including the conditions on back hereof, which are hereby agreed to by the shipper and accepted for himself and his assigns.

(Mail or street address of consignee—For purposes of notification only)

Consigned to,

Destination State of County of

Route

Car Initial Car No.

(Delivering carrier)

| NO. PACKAGES | DESCRIPTION OF ARTICLES, SPECIAL MARKS AND EXCEPTIONS | *WEIGHT (Subject to correction) | CLASS OR RATE | CHECK COLUMN |
|---|---|---|---|---|
| | | | | |

If this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement.

The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges. (See section 7 of conditions)

(Signature of consignor)

If charges are to be prepaid, write or stamp here "To be Prepaid"

Received

$________

to apply in prepayment of the charges on the property described hereon.

Per________

Agent or Cashier.

Per________

The signature here acknowledges only the amount prepaid.

Charges Advanced:

$________

This is to certify that the above articles are properly described by name and are packed and marked, and are in proper condition for transportation, according to regulations prescribed by the Interstate Commerce Commission.

Shipper's imprint in lieu of stamp, not a part of bill of lading approved by the Interstate Commerce Commission.

The fibre boxes used for this shipment conform to the specifications set forth in the box maker's certificate thereon, and all other requirements of Rule 41 of the Consolidated Freight Classification.

Shipper's imprint in lieu of stamp, not a part of bill of lading approved by the Interstate Commerce Commission.

*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight."

NOTE—Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.

The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding

..................per..................

1

THE FIRESTONE TIRE & RUBBER CO., Shipper ........................................Agent

Per........................................ Per........................................

*Permanent post-office address of shipper* FIRESTONE PARK, AKRON, OHIO

*Courtesy—The Firestone Tire and Rubber Co.*

FIG. 75

A BILL OF LADING

**Closing Out the Purchase Order.** When the shipment has been received and the goods and the invoice found to agree with the purchase order, the invoice is certified by the invoice clerk to the purchasing agent for payment. A voucher for the payment of the invoice is written. A voucher is a properly approved authorization of payment and a request for the issue of a check to the vendor. The purchasing agent approves the invoice and signs the voucher. These papers are forwarded to the accounting department. After any necessary records have been made, the voucher is forwarded to the treasurer's office, from which a check is issued to the vendor. This closes out the order as far as the purchasing department is concerned.

The above routine is merely illustrative. While it is fairly typical, the routine for any given company must be developed to meet its particular conditions.

# CHAPTER XVII

## THE CONTROL OF MATERIAL
## INVENTORY CONTROL—STANDARDS—SALVAGE

**The Balance of Stores Department.** The balance of stores department, or stores record section as it is sometimes called, is responsible for the clerical control of inventories. The department may be composed of two sections—the ledger section and the order section. The ledger section maintains records of material inventories. It apportions material against orders. It posts the material requisitions and credits to the stores ledgers. It may price them and extend their values. When the available supply of a given item of material falls to the ordering point, it notifies the order section, which initiates the procurement of a new supply of the material and follows the work of procurement to see that the material is in stores before the supply on hand is exhausted. This and similar work constitute the field of the balance of stores department. To perform its functions properly, it should receive some evidence of every transaction which affects the value or disposition of the material inventories.

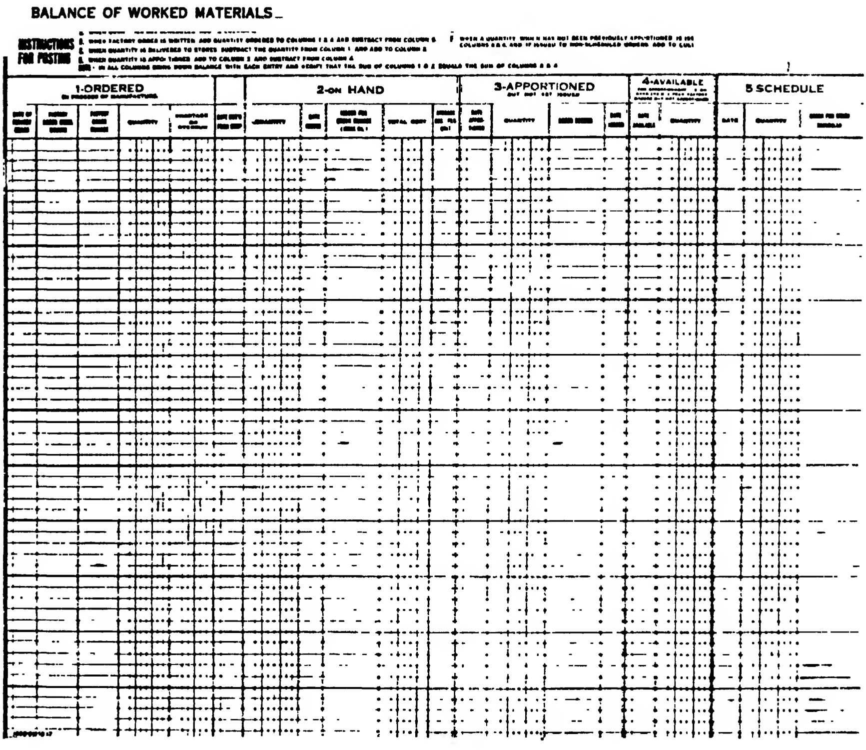
**The Stores Ledgers.** The principal advantages of a good ledger control inventories are:

(1) It assists the production organization in the planning of production.
(2) It aids in reducing the number of delays to production resulting from lack of material.
(3) It facilitates the work of the stores department in the filling of requisitions and the delivery of material.
(4) It tends to reduce interest charges by holding inventories to a minimum.
(5) By so doing, it aids in reducing the losses from the depreciation and deterioration of inventories.
(6) It aids in coordinating the work of inventory control and purchasing.
(7) It aids in coordinating more closely the work of materials, production, and cost control.
(8) It reduces or eliminates the cost of physical inventories.
(9) By watching consumption figures, often it is possible to reduce the number of items carried in stores by eliminating many that are unnecessary.

There are two distinct types of stores ledgers—the Barth type and the Gantt type. Most of the better ledger sheets in use today are developments or variants of these two types.

Fig. 76 is an example of a Barth ledger sheet. The "On Order" column is intended to coordinate the work of purchasing and inventory

control. The "On Hand" column furnishes a current record of the inventory of the particular item of material. In addition, it furnishes a record from which the usage of the item can be determined. The "Apportioned" column is intended to correlate the work of planning and inventory control. It shows the amount of material which has been set aside against orders which have been planned, but not yet



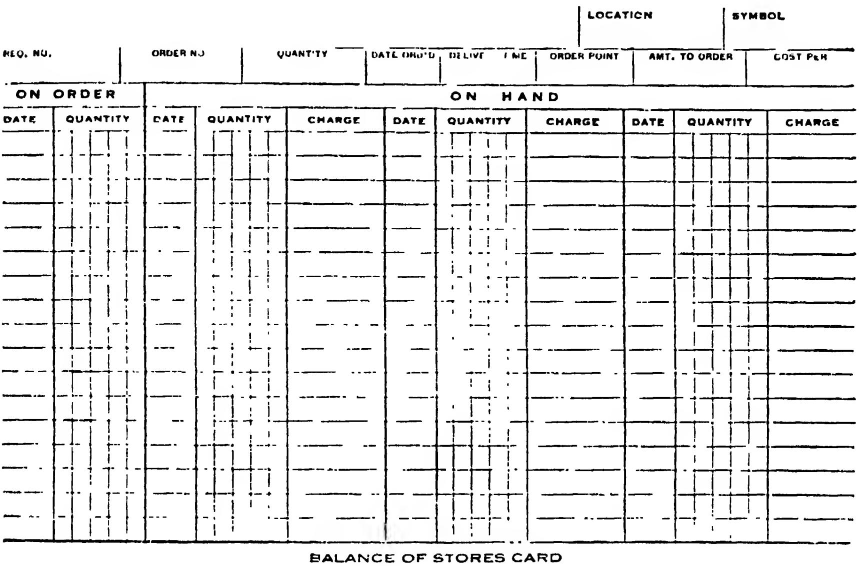

*Courtesy—Winchester Repeating Arms Co.*

FIG. 76

THE BARTH LEDGER SHEET

put in process. It insures the availability of the material when it is needed. The "Available" column shows the amount of the item which is available for new orders. When a purchase order for the item is placed and accepted, the purchase order number, date, and quantity ordered is entered in the "On Order" column. At the same time, this information is entered in the "Available" column. If the minimum ordering quantity has been fixed properly, the quantity ordered will be in stores before the present supply is exhausted, unless unusual

conditions arise. Consequently, it is available for apportionment against new orders. When the order is received, the quantity is deducted from the amount on order and is added to the total quantity in the "On Hand" column. When a requisition[1] is apportioned, the quantity required to fill the requisition is added to the total quantity in the "Apportioned" column, and at the same time it is deducted from the total in the "Available" column. While the quantity on the requisition has not yet been delivered from stores, it is no longer available in connection with the planning of new orders. When the requisition




*Courtesy—John A. Fisher.*

FIG. 77

THE GANTT LEDGER CARD

is presented to the storeroom, the required material is delivered and the requisition is forwarded to the balance of stores department. When it is received, the ledger clerk posts the requisition to the ledger sheet for the particular kind of material. He deducts the quantity on the requisitions from the totals in the "On Hand" and "Apportioned" columns. When a requisition is received which has not been apportioned previously, the quantity issued is deducted from the totals in the "On Hand" and "Available" columns. The accuracy of the entries can be checked at any time. The quantity on order plus the quantity on hand should always equal the quantity apportioned plus the quantity available. The ledger sheets are filed by classes of materials and the

[1] See page 257.

numbers or symbols for each individual item of material. If no number or symbol system has been developed, they may be filed alphabetically within each class.

In the Gantt System, there is a card for each purchase order for each item of material. The cards for a given item are filed together in sequence of order numbers. The cards for the various items of material are filed according to material classes as previously indicated. When material is issued, the quantity on the requisition is deducted from the card for the oldest order. The requisition is priced at the unit price of this order. When the quantity on this card has been used up, further issues of the material are deducted from the card for the next oldest order. In the case of material procured by manufacture, the cards would be handled in the same way, the cards for a given item of material being filed according to production order numbers. Fig. 77 shows a Gantt ledger card. In its original form, the ledger card has no space for apportioning material against production orders. Where there is a fairly steady use of the material, it may not be necessary. In many cases, such a condition is more the exception than the rule. To get an idea of the availability of material, it would be necessary to compare the amounts on hand and order as shown by the cards for a given item, with the requirements for the item on orders planned but not yet in process. Such a procedure would be too cumbersome to be practical. As a result, in some cases an "Apportioned" column has been added to the card.

**The Control of Inventory Values.** In some plants the stores ledgers are used only for quantity control. In such cases there may be no direct connection between the stores ledgers and the general books of the company. The chief function of the stores ledger is to serve the needs of the production organization. However, it is better to link up quantity control and value control in the stores ledgers and to tie them into the general and cost-accounting systems. To do this, the unit value of each item of material must appear on the stores ledger sheets.

There are three methods of pricing stores requisitions and credits. They are (1) the average unit-price method, (2) the lot-price method and (3) the market price method.

With the average unit price method, each requisition is priced at the average cost of the material on hand. The advocates of the method feel that. inasmuch as the use value of each piece of a given material is the same regardless of when it was bought, it is incorrect to charge a higher material cost for one order than another merely because of fluctuations in prices. The price and cost columns under the heading "On Hand" on the Barth sheet, are intended for use with this method. When the purchase order routine has been completed and the invoice

has been approved for payment, the purchasing department forwards to the balance-of-stores department a memorandum giving the quantity on the order, the unit price of the material, total cost, and any other information which may be required. When this memorandum is received, the ledger clerk enters the price and cost information opposite the quantity received on the order, under the heading "On Hand." The quantity received may have been entered previously from the material-received sheet. In this case some adjustment may be necessary if part of the order already has been issued to the shop. The quantity on hand previous to the receipt of the shipment is multiplied by the old average unit price and its cost extended. The cost of the shipment is added to this cost, and total value is divided by the new total quantity on hand to get the new average unit price. As requisitions are received subsequently, the ledger clerk enters the new average unit price on each requisition until the receipt of another shipment again changes the unit price. If the material is procured from the shop on a production order, the unit cost and total cost of the order will be received from the cost department. Otherwise the procedure is the same.

The Gantt ledger cards are intended for use with the lot-price method. As in the previous case, the balance-of-stores department receives from the purchasing department a memorandum of the unit price and total cost of an order of a given item of material. This information is entered on a ledger card for that order. As requisitions for the material come to the ledger clerk, they are priced at the unit price of the oldest order on hand. When the quantity on that order is used up, further requisitions are deducted from the card for the next oldest order. The requisitions are priced at the unit price on that card, which may be considerably different from the price on the previous card. In favor of this method, it may be said that, theoretically at least, the oldest material in stores is always used up first. The material cost of an order tends to approximate more closely the actual cost of the material used for it. At times, the use of the lot price may cause greater fluctuations in material costs than under the average unit-price method.

Under the market-price method of pricing, the stores requisitions and credits are priced at the market price of the material at the time the material is issued. Monthly, or if necessary more often, the purchasing department submits to the balance-of-stores department a list of the current market prices of the items of purchased material carried in stores. As material is purchased, it is charged into the inventory controlling accounts of the general ledgers at the invoice price. As material is issued, it is credited to these accounts at the market price.

The unit prices on the stores ledger sheets are the current market prices. All requisitions and credit slips are priced at these prices. When a physical inventory is taken at the close of a period, this inventory also is priced at the current market prices. The balance of the inventory controlling accounts, less the market value of the inventories on hand, is the amount of profit or loss which has resulted from the operations of the purchasing department. The objection to this method is that it may tempt the management to use the purchasing department for the purpose of acquiring speculative profits. Furthermore, the cost records will not show the actual material costs of orders processed in the shop. Usually, this is not considered desirable from a managerial standpoint.

**Inventory-controlling Accounts.** As stated previously, the materials division is interested in the procurement and control of material inventories which may be classified as general stores, worked materials, component-parts stores, finished stores, salvage stores, and unclassified stores. Usually, inventory-controlling accounts are set up in the general ledger on the basis of some such classification. The controlling accounts are summaries of the accounts in the stores ledgers for the individual items of material. Of these accounts, the materials division is least interested in worked materials, for the reason that work-in-process is not usually put into stores. The work-in-process accounts are the cost records. In plants carrying large and varied inventories there will be a number of controlling accounts in each of the general classifications indicated above. Fig. 78 shows part of a classification of such accounts. Where the inventories have been properly classified and symbolized, it is better to arrange the sheets or cards in the stores ledgers according to the controlling accounts in which the individual items fall. If the symbol system has been properly devised, the symbol for a given item of material will show the controlling account under which it falls, and will automatically locate the proper sheet for the material in the stores ledger, facilitating the posting of requisitions and credit slips.

As the material requisitions and credit slips are received by the ledger clerk from the stores department, they are entered in the ledgers and priced as previously explained. They are then turned over to clerks who extend on each requisition and credit slip the value of the material withdrawn. The correctness of the extensions is checked by other clerks who sort the requisitions and credit slips by controlling accounts and take off the total for each account. The requisitions for each account are bundled together, with a memorandum showing the total value of the requisitions in each bundle, and are forwarded to the accounting department. The credit slips are handled in a similar

Issued by;
Planning Dept.

Effective October 1st.,1921
Superseding all previous lists

## "S" STORES CONTROLLING ACCOUNTS

| | |
|---|---|
| SB | Stationary |
| SC | Copper |
| SD-K | Flat Cutlery (Special Stores)Raw Material |
| SD-P | Pocket Cutlery (Special Stores)Raw Material |
| SD-S | Scissors and Shears (Special Stores)Raw Material |
| SE | Coal |
| SF-C | Auger Bits,Chisels,Carpenters.HammersmScrew Drivers (Special Stores)Raw Material |
| SF-K | Planes (Special Stores)Raw Material |
| SF-L | Machinists Hammers (Special Stores)Raw Material |
| SF-R | Wrenches,Pliers (Special Stores)Raw Material |
| SG-B | Gun Bags - Cloth and Paper |
| SG-K | Gun Lumber |
| SG-L | Gun Labels |
| SG-N | Gun Steel |
| SG-W | Gun Wooden Packing Cases |
| SG-X | Gun Paper Packing Boxes |
| SH-A | Tool Blanks |
| SH-B | Forging Die Blocks - Heppenstahl |
| SH-C | Carbon Drill Rod and Class 4 Steel |
| SH-D | Class 6 Steel |
| SH-E | Nut piercing Steel Class F - Midvale |
| SH-F | Finishing Steel,Class 3A and 3B Steel |
| SH-H | High Speed Drill Rod |
| SH-S | Class 1 Steel |
| SH-V | Samson and Awk Vanadian Steel |
| SJ | General Hardware |
| SK-B | Cartridge Labels |
| SK-D | Lead |
| SK-E | Cartridge Crucibles |
| SK-L | Wads and P.S.S.Compinents |
| SK-M | Cartridge Metals and their Alloys |
| SK-P | Powder and all Explosives |
| SK-W | Cartridge Wood Packing Cases |
| SK-X | Cartridge Paper Boxes |
| SK-Y | Cartridge Machine Parts |
| SL | Builders Hardware (Special Stores for) |
| SM | Household Goods (Special Stores for) |
| SN | Paints,Oils and Auto Acc.,(Special Stores for) |
| SP-L | Flashlights and Batteries (Special Stores )Raw Material |
| SP-B | Bait,Fishing Acc.,Stringers,Disgorgers Etc.(Spl.Stores)Raw Material |
| Sp-R | Reels and Rods (Special Stores )Raw Material |
| SR | Rejected Goods |
| SS | Spelter |
| ST-A | Misc.,Tools |
| ST-B | Abrading Tools |
| ST-C | Clamps and Holding Devices |

FIG. 78

A Classification of Stores Controlling Accounts

manner. In the accounting department, the totals for each bundle are checked and posted to the proper controlling accounts. The requisitions are then forwarded to the cost department. In the cost department, they are resorted according to the order number appearing on the requisition or credit slip. The slips for each order number are then posted to the cost card for that order.

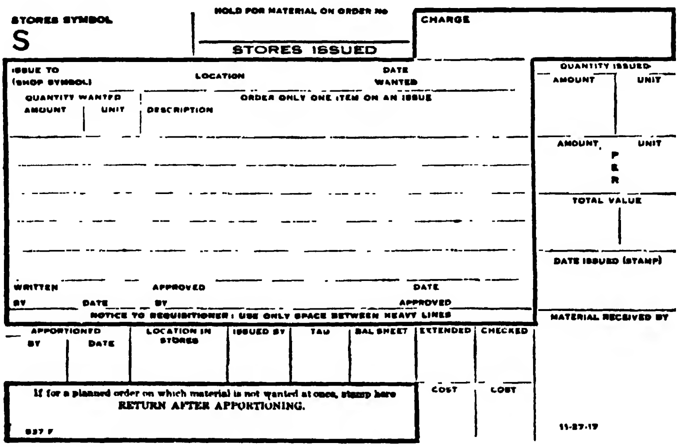
**Units of Issue.** On the ledger card or sheet will be found the term, "Unit," which refers to the unit of issue. To illustrate, certain kinds of steel may be bought by the pound, but may be issued to the shop by the foot. Obviously, the unit price which appears on the ledger sheet must be the price in the unit in which the material is issued, not the price in which it is purchased. This means a conversion of units which introduces a certain amount of error which cannot be avoided. Again from the standpoint of economy in handling in the storeroom, it may not be advisable to issue small items of low unit value individually. For instance, it may be better to put up small screws in lots of twenty-five and issue them in these lots rather than to fill requisitions for odd numbers of screws. The time of the stores clerk which would be consumed in counting out the screws would be worth more than the value of any screws which could be saved. On the ledger sheet, the unit price of these screws would be the cost of twenty-five screws.

**The Material Requisition.** The material requisition, or stores issue as it is called in some cases, is the written authority for the withdrawal of material from stores. It transfers the responsibility for the material from the materials division to some other department and charges it to a particular order. When the requisition is received in the balance-of-stores department, the ledger account for the material is credited. Elsewhere, some other account is charged. To illustrate, if the material is for some production order, the requisition will be the basis for an entry on the cost card for the order, when it is received in the cost department. Fig. 79 shows a material requisition and indicates the information usually found on it. The material symbol identifies the material and the account under which it is carried in stores. The term "location" refers to the location of the material in the storeroom. If orders are preplanned, the location symbol, shown on the ledger sheet, will be entered on the requisition when the order is apportioned. In large plants, the storeroom may cover a considerable area. There are hundreds of bins in which are materials of all kinds. The location symbol facilitates the work of the stores clerks in filling the requisition.

The information, "Deliver" and "Date Wanted," is used when the stores department delivers the material to the department which requires it. In the case of material for production, the planning depart-

ment, in planning an order, may enter on the material requisition the department which will require it and the date when the material should be delivered. After it has been apportioned, the requisition is forwarded directly to the stores department and filed in a tickler file against the date when the material is to be delivered. On this date, the requisition is taken out of the file, is filled by the stores clerks, and is delivered to the department by the internal transportation system. When the material is delivered, the requisition is receipted by the shop foreman and returned to the storeroom which forwards it to the balance of stores department.

In the space "Charge" is entered the order number to which the material is to be charged. At the bottom of the requisition are a num-


STORES SYMBOL
S
HOLD FOR MATERIAL ON ORDER No
STORES ISSUED
CHARGE
ISSUE TO (SHOP SYMBOL)
LOCATION
DATE WANTED
QUANTITY WANTED
AMOUNT | UNIT
DESCRIPTION
ORDER ONLY ONE ITEM ON AN ISSUE
QUANTITY ISSUED
AMOUNT | UNIT
AMOUNT PER UNIT
TOTAL VALUE
DATE ISSUED (STAMP)
WRITTEN BY
DATE
APPROVED BY
DATE APPROVED
NOTICE TO REQUISITIONER: USE ONLY SPACE BETWEEN HEAVY LINES
MATERIAL RECEIVED BY
APPORTIONED BY | DATE
LOCATION IN STORES
ISSUED BY
TAG
BAL SHEET
EXTENDED
CHECKED
COST
COST
If for a planned order on which material is not wanted at once, stamp here
RETURN AFTER APPORTIONING.
837 F
11-27-17

*Courtesy—Winchester Repeating Arms Co.*

FIG. 79

A Material Requisition

ber of check blocks for checking the progress of the requisition through the clerical operations which are performed on it.

The material requisition may originate from two sources—the planning department or some authorized executive. As explained in Chapter 10, part of the work of the planning department may be to write requisitions for material required for new orders. These requisitions are forwarded to the balance-of-stores department to be apportioned. After apportionment, they are returned to the planning department. At the proper time, the planning department dispatches the requisitions to the department which requires the material or to the stores department, depending on the system in use. Requisitions for certain classes of material are originated by certain authorized executives. In the case of such expense materials as waste, used by the employees in clean-

ing their machines, the requisitions usually are written by the shop foreman when he needs them. In some plants, all requisitions are written by the executives as they need materials or supplies. Obviously, the control of materials is less complete in such cases.

**The Stores Credit Slip.** Sometimes all of the material withdrawn for use on an order is not consumed. This material should be returned to stores with a "stores credit" slip, an example of which is shown in Fig. 126. This slip credits the order for which the material was withdrawn and charges the stores ledger account for the material. A more common case is the delivery to stores of finished component parts or finished product. In this case, the stores ledger account is charged and the work-in-process account, as shown by the order number, is credited. The information contained on the stores credit slip is similar to that on the material requisition and it is handled in much the same manner. The credit slip for worked material is usually so designed that it can be easily distinguished from the ordinary credit slip.

**Handling Unclassified Material.** Unclassified stores includes all material not stocked regularly by the stores department. A piece of machinery may be purchased for the shop or equipment for the office. While such material probably will not be carried regularly in stock, the materials division is responsible for it until it is delivered to the department where it will be lodged permanently. The receipt and disposition of all material purchased by the plant must be recorded. Another shipment of the same item may never be received again. Therefore, it is a waste of time to make out a ledger sheet for the shipment. For this reason, some concerns use a copy of the purchase requisition as a ledger sheet for unclassified purchased material. This copy has on its back a printed form which permits its use in place of the regular ledger sheet. It shows merely the receipt of the material, quantity, value, and disposition. For the most part, unclassified material is not kept in the storeroom for any great length of time. It is moved to the department for which it is intended as soon after its receipt as possible, in order to get it out of the way. Unclassified manufactured material may be handled similarly by means of a copy of the manufacturing requisition.[1]

**Physical Inventories.** In order to take inventory, many concerns close down annually or semiannually for periods ranging from two days to two weeks, depending on the size of the plant and the thoroughness with which the work is done. At such times, a count of all materials, supplies and work-in-process is made. In most cases, the inventory is anything but exactly accurate. If the stores ledgers are

[1] Special provision must be made for handling miscellaneous unclassified material.

checked continuously against actual stocks in the storeroom,[1] the inventories shown on the ledgers will be more accurate than the average physical inventory. Many concerns, using modern balance-of-stores methods, do not take physical inventories of materials and supplies, saving thereby considerable inventory expense and valuable production that would otherwise be lost.

**The Relations of the Balance of Stores to the Planning Department.** There is a close relation between the work of the balance-of-stores department and the work of the planning department. In the course of the day, the two are in constant contact. For this reason, the stores ledgers are placed under the control of the planning department in some organizations. In the organization which has been developed for illustrative purposes, a separate division has been set up for the handling and control of material problems. Under such conditions, it is better that the stores ledgers be placed under this division. If the responsibility for the control of materials is to be placed on the materials division, it should have jurisdiction over the chief instrument for their control, the stores ledgers.

**The Standards Section.** The standards section is responsible for the determination of standards and methods for the materials division. If the organization has a methods manager, much or all of this work may be done under his direction. If it does not, it may be necessary to set up some such organization as the standards section, to insure that there will be an orderly, logical development of methods and standards for the materials division. The extent to which a function is developed depends on the size of the plant and the nature of the problem as well as the nature of the function. In the average plant, it may be sufficient to place the responsibility for the development function on some one individual, such as an assistant to the materials manager, rather than to set up a separate section.

The standards section may perform such work as the control of material specifications, the determination of maximum and minimum ordering quantities, the symbolization of materials, the development of stores methods, and similar work.

**Maximum and Minimum Ordering Quantities.** The minimum ordering quantity is intended to indicate when the stock of a given material is running too low. When the quantity in the "Available" column of the stores ledger sheet falls to the minimum ordering quantity, the order clerk of the balance-of-stores department is notified by the ledger clerk and a purchase requisition is placed with the purchasing department. In the case of purchased materials, the ordering point depends

[1] See page 286.

on the rate at which the material is being consumed and the time required to procure a new supply.

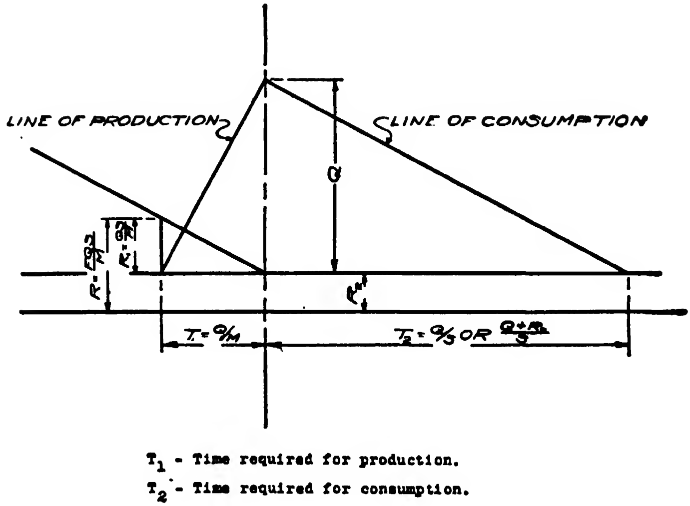



FIG. 80
THE CURVE OF MANUFACTURING

Fig. 80 indicates the relations governing the manufacture of a given quantity of material. In the diagram,[1]

R = the minimum ordering point.

$R_1$= the theoretical minimum ordering point. If an order for a new supply of material is placed when the quantity available is reduced to this point, the new supply will be received at the time when the quantity available is entirely exhausted.

$R_2$= a reserve stock to meet such contingencies as delays in the delivery of material.

Q = the minimum cost quantity or ordering quantity, expressed in pieces.

$T_1$= the time required to manufacture a new supply of the material, expressed in years.

M = the rate at which the quantity is manufactured, expressed in pieces per year.

S = the rate at which the material is being consumed, expressed in pieces per year.

Then, $R_1 = ST_1$ and $T_1 = Q/M$. If F is a factor, representing the ratio of R to $R_1$, then,

$$R = FR_1$$
$$= FST_1$$

M

With many concerns, the determination of the minimum ordering quantity is a matter of cut and try. However, their results tend to

[1] See article by author, "Manufacturing Industries," April, 1925.

conform to the above relation. For purchased material, the time required to procure a new supply depends on the time required to originate a purchase requisition, go through the routine of purchasing, possibly produce the goods in the plant of the vendor, ship the goods to the vendee's plant, and place them in stores. It will vary from a matter of days to months, depending on the nature and location of the source of supply and the character of the material.[1] In the case of manufactured materials, the time required for procurement depends on the time required to originate a manufacturing requisition, get the order through the planning department, manufacture and place the material in stores. The rate at which the material can be produced is an important factor.

The maximum ordering quantity, Q, is the greatest quantity in which the material is normally ordered. It should also be the quantity which can be manufactured at the least unit cost. It depends on the rate at which the material is consumed, the time required for the procurement of the quantity, the preparation cost of manufacturing, the cost of storage and similar factors. The smaller the quantity manufactured, the less are the interest charges, the cost of storage and handling, and the danger of deterioration, depreciation, and loss. The amount of capital tied up in inventories is smaller. On the other hand, the smaller the quantity manufactured, the greater will be the unit preparation cost of manufacturing. If the quantity manufactured on an order is too large, the interest and storage charges on the quantity, while it is gradually being withdrawn from stores, will be so great that the unit cost of the order will be high. On the other hand, if the quantity manufactured is too small, the unit cost of setting up and adjusting the necessary machinery and preparing to manufacture will be too high. Somewhere between these two conditions, there is a quantity which can be manufactured at a minimum unit cost. It can be demonstrated that the quantity which can be manufactured at least unit cost is,

$$A$$

in which A is the preparation cost of manufacturing, K is a constant representing the influence of the interest charges, and H is a constant representing the influence of the storage charges.[2] Other things being equal, the quantity that can be manufactured at least unit cost varies

[1] For a discussion of the ordering point for purchased material, see article by author in *Manufacturing Industries*, May, 1927.

[2] See article by author in the August, 1926, issue of *Manufacturing Industries*.

directly as the square root of the preparation cost of manufacturing and inversely as the square root of the interest and storage charges.

The influence of the interest charge depends, in part, on the relation of the time when the old stock is completely exhausted to the time when the new stock is completely manufactured. In other words, it depends on the value of F. The following table gives the corresponding values of F and K.

| F | K |
|---|---|
| 0.25 | $\frac{(M - 0.5S)}{2MS} C'I$ |
| 0.50 | $\frac{C'I}{2S}$ |
| 0.75 | $\frac{(M + 0.5S)}{2MS} C'I$ |
| 1.00 | $\frac{(M + S)}{2MS} C'I$ |
| 1.25 | $\frac{(M^2 + 1.5MS + 0.5S^2)}{2M^2S} C'I$ |
| 1.50 | $\frac{(M + S)^2}{2M^2S} C'I$ |

In the above equations for "K"—

$C'$ = The standard unit cost of the item.

$I$ = The current rate of interest, expressed in dollars per year.

Similarly, the influence of the storage charge also depends on F. The following table gives the corresponding values of F and H.

| F | H |
|---|---|
| 0.25 | $\frac{(M - 0.5S)}{MS} BE$ |
| 0.50 | $\frac{BE}{S}$ |
| 0.75 | $\frac{(M + 0.5S)}{MS} BE$ |
| 1.00 | $\frac{(M + S)}{MS} BE$ |
| 1.25 | $\frac{(M + 1.25S)}{MS} BE$ |
| 1.50 | $\frac{(M^2 + 1.5MS + 0.5S^2)}{M^2S} BE$ |

In the above equations—

B = bulk factor, expressed in square feet of net storage space required per unit of item.

E = storage charge, expressed in dollars per square foot of net storage space per year.

The following example will illustrate the method of determining the ordering quantity. The piece being manufactured is small, so that about 200 pieces can be stowed in a bin having a cubical content of approximately one cubic foot. There are eight tiers of bins in each bin stack. In this case the standard depth of bin is assumed to be one foot to simplify the problem. Therefore,

$$B = \frac{1}{200 \times 8}$$

$$= 0.000625 \text{ sq. ft. of net floor space per piece.}$$

The term net floor space means the net usable floor space, exclusive of aisles, steel bin frames, and similar dead space, against which all direct and indirect storage charges must be resolved.

E = \$3.00 per sq. ft. per year.
M = 50,000 pieces per year.
S = 2,000 pieces per year.

Let us assume that pieces from the new lot will be available in stores

when manufacturing has been about one half completed. Under these conditions, $F = 0.5$. Assume also that $C' = \$2.50$, $I = \$0.06$ and $A = \$200$. Then,

$$H = \frac{BE}{S} \text{ or } \frac{0.000625 \times 3}{2{,}000}$$

$$= 0.000000938, \text{ and,}$$

$$K = \frac{C'I}{2S} \text{ or } \frac{2.5 \times 0.06}{2 \times 2{,}000}$$

$$= 0.0000375. \text{ Therefore}$$

$$= \sqrt{\frac{A}{K + H}} \text{ or } \sqrt{\frac{200}{0.0000375 + 0.000000938}}$$

$$= 2{,}280 \text{ pieces, approximately.}$$

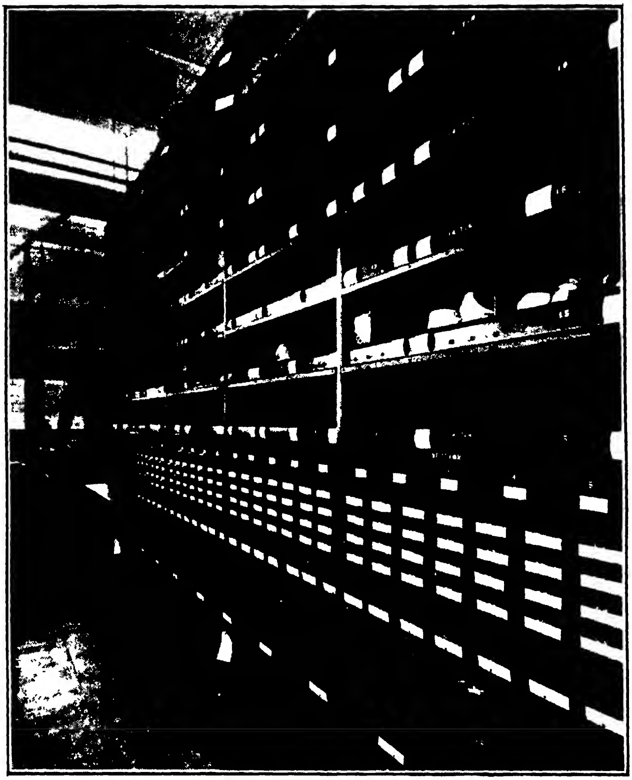
In a very few plants is the quantity to be manufactured determined in a rational manner. In most cases, it is a matter for the experience and judgment of some executive assumed to be competent in such matters. Yet the proper determination of ordering quantities is a vital factor in the turnover of working capital and the economy of manufacturing. In some instances an effort is made to determine whether ordering quantities are too high or too low and to control inventories by recording graphically, the monthly figures of consumption and stocks on hand for each of the important items of material carried in stores.

A technique, similar to that explained above, can be applied to the determination of proper purchase quantities.[1]

**Material Standardization.** A standard is that which has been set up as a unit of reference. It may be any generally accepted criterion. In material standardization, it is that combination of characteristic attributes which materials should have to meet a given purpose to the best advantage. It is desirable to determine what materials most closely approach such standards and to confine the list of items carried regularly in stock to them. Unless this is done, it is probable that the stores department will carry many items whose uses overlap one another to a considerable extent. This tends to reduce the rate of inventory turnover, increase interest charges, the cost of handling, and the storage space required.

In studying the list of items carried in stores with a view to standardizing them, four general considerations must be kept in mind: (1) To how many uses is a given item of material put. It may be used in a number of departments in connection with the manufacture of widely differing products. (2) What materials resemble it. It may be found that different materials are used in the manufacture of different parts or products, although in many cases the requirements

[1] See article by author in May, 1927, issue of *Manufacturing Industries*.



*Courtesy—Durand Steel Locker Co.*

PLATE 17

SHEET STEEL BINS

of the materials may be identical for all practical purposes. (3) What substitutes may be used. The analysis may indicate certain substitutes which may be used in place of a given standard material when sufficient supplies of the standard material are unavailable on the market. (4) What are the characteristic attributes of each material selected as standard for a given purpose. Before any particular material can be selected as a standard material for a given purpose, the conditions which the material must meet in use must be determined. It is then necessary to determine the characteristic attributes which the material should have to meet these conditions satisfactorily. Consideration must be given to salability of the product as well as the needs of the production organization.

In most cases the material standards are a composite of the experiences of a number of divisions of the organization. The engineering department is able to contribute information concerning the relative efficiencies of different materials and the characteristics which they should have to meet the engineering requirements. The sales department is able to contribute information relating to the effects of given materials on the salability of the product. The purchasing department is able to contribute information regarding the costs of different materials. The production organization is able to contribute information regarding the relative ease and satisfaction with which they can be processed. Because information from a number of different sources is needed, it is desirable to have the work of the standards section supervised by the materials committee. Such a committee, composed of representatives of the departments affected by material standardization, will insure that the problem will be handled from the standpoint of the needs of the organization as a whole rather than the immediate needs of the materials division. Furthermore, it is in a position to promote the application of the principles of standardization to other fields of material control, with beneficial results.

Data regarding each class of materials may be compiled for the committee by the standards division or the analysts of the methods division, depending on the nature of the organization and its methods. The various materials, their uses, their requirements and other pertinent data, are tabulated, and those having similar uses are compared to determine which can be eliminated. Finally a statement of the required properties is drawn up for each item which is to be carried regularly in stores.

When some such procedure is followed, the result usually is a reduction in the number of different items carried in stores. The quantity of any given standard item which can be purchased at one time, economically, is increased. This may make it possible to secure

more advantageous prices. With a smaller number of items and larger individual usage, it should be possible to control inventories more closely. This, in turn, should result in relatively smaller inventories and a more rapid turnover of working capital invested in them, with consequent savings in interest and storage charges, less danger of depreciation and obsolescence, and possibly fewer stores employees due to the bulk handling of materials.

**Material Specifications.** In working up specifications for materials, there is available not only the combined knowledge of the various departments of the organization, but also various sources of information outside of the organization. Many of the large technical societies have standard specifications for most important materials. Quite often, manufacturers' catalogues contain much technical information about the materials which they describe, which is valuable. The United States government publishes a general schedule of supplies which contains specifications for the great variety of materials purchased by it. Using such sources of information, many concerns write specifications for each item regularly carried in stores. The specification for a particular material will contain such information as,

(1) Name of item.
(2) Material symbol.
(3) General description of the material.
(4) Statement of its uses.
(5) Statement of its chemical and physical properties.
(6) The qualities desired.
(7) Specifications relating to methods of packing, containers, labels, etc.
(8) Permissible substitutions for the standard material.
(9) Method of inspection and any tests to be applied in the receiving of the material.

No changes in specifications should be permitted unless approved by the materials committee. Responsibility for the maintenance of specifications should be centralized in the standards sections of the materials division under the supervision of the committee.

Requests to purchase unclassified material or to stock some item which has not been carried previously are received from time to time. Such requests should be scrutinized carefully to see if there is not some standard material which can be used. If there is, of course it should be substituted for the material requested.

**Symbolizing Materials.** Classification is the basis of good records. With the present high development of industry, it is hardly possible to operate efficiently without good records. The clerical work of recording a large number of items, divided and subdivided into many classifications, is greatly facilitated by the application of a logical system of symbols to these items. As a result, almost every concern has applied, in some measure, the principle of symbolization to some

phase of its operations. In some plants there may be a number of symbol systems for various phases of the work of management, none of which may be related to each other in any logical way. To illustrate, a production order for a given part may bear the symbol P101. The symbol by which the materials division identifies the part may be a simple number, such as 1126. In addition, the engineering department may have assigned a number to the part which is entirely different. The more information which has to be recorded in connection with a clerical operation, the greater is the chance of error. Therefore, it is undesirable to employ three systems of symbols if one can be devised which will serve all three purposes adequately.

A symbol may be defined as a concise representation of a name and a description. While the materials division is chiefly interested in the problem of symbolizing materials, any symbol system to be fully useful, should tie in with the accounting and production systems. Therefore the symbols should be concise representations of the names and descriptions of accounts as well as of materials. This is entirely reasonable because the results of any business are finally expressed, in terms of dollars, in the general ledger accounts. As far as possible, the items to be symbolized should be classified according to the classification of accounts in use. To facilitate identification, there may be many sub-classifications under each class. The symbol for each item must be distinctly different from every other symbol in the system.

There are three general types of symbol systems, the numerical, alphabetical, and combinations of the two. In the numerical system, a series of numbers is applied to the items to be symbolized. Sometimes an attempt is made to indicate the various classes of items by breaking the series into groups. For instance, the numbers 1 to 999, inclusive, may be reserved for one class of items, the numbers 1,000 to 1,999 for the next class, etc. Such a system has the disadvantage that there is nothing in the symbol itself to identify the item unless one can remember the arbitrary divisions of numbers which have been established. Even then, there is always the possibility of confusion, for the reason that the same number may mean a number of different things when there are a number of numerical systems in use in the plant. A given number, say 1,166, may be an employee's clock number, an order number, a material number, or something else. To avoid this, more complicated numerical systems have been devised. In the Dewey decimal system, the number is broken up into a number of groups by the use of decimals. It might be more accurate to say that the symbol is a composite number made up of several related numerical series. In the case of some symbol such as 113:248:523, the number 113 might represent the general class in which the item falls, the number 248 the particular class, and the number 523 the particular

item. In a large plant it is impossible to remember the meaning of the thousands of symbols in use. Therefore it is necessary to compile a code book to which reference can be made when it is necessary to select a symbol or an item which does not occur regularly. While some attempt has been made to apply this principle to industrial uses, it has not been introduced widely, for the reason that it is too cumbersome.

While the numerical system has its disadvantages, there are cases where it is desirable to use it. An instance of this is the use of a numerical system in connection with the use of mechanical tabulating devices.

In the alphabetical system, letters are used to indicate the classes, sub-classes and particular designations. Both the letter itself and its position in the symbol have a meaning. To illustrate, the first letter in the symbol might indicate the general class in which the item falls, the second letter the sub-class, and the third letter the item itself. By dividing and subdividing the various classes and sub-classes, the system can be extended to cover as many different items as need be. However, the more the classifications are refined, the more letters appear in the symbol until it becomes so cumbersome that it tends to defeat its purpose of furnishing a convenient, logical system of identification and classification.

**The Mnemonic System.** By using a combination of numbers and letters it is possible to devise a system of symbols which will avoid the previous objections to a considerable extent. The best known of such systems is the mnemonic system. The term mnemonic means to aid the memory. Therefore a mnemonic symbol system is one in which the symbols suggest the identity of the items which they represent. The idea of mnemonic representation is not new. In modern science and engineering, mnemonics have long been used. The symbols which the chemist uses to designate various elements are to a large extent mnemonic.

Words have varying interpretations. Papers and communications which are hastily written under pressure of the day's work are always in danger of being misunderstood. If the paper originates in the shop, it may be written crudely and the difficulty of deciphering it may be increased by the fact that it is smudged with grease and dirt. If the product and production problems are complicated, the need for exact identification of each paper originated in connection with production control is increased. It is said that the ten-inch disappearing gun carriage is composed of 4,000 parts, made from 50 different materials, on each of which are performed from 10 to 100 operations.[1] It is

[1] "The Index as a Factor in Industry," by John H. Williams, Bulletin of The Taylor Society, May 1915.

obvious that in the manufacture of such a complicated product a great number of papers of various kinds must be originated. Their handling and the control of production are greatly facilitated if they can be easily and quickly identified by those who receive them. Much of the possibility of error is eliminated if the extended, written description of an item is supplemented or replaced by a short, concise symbol. In addition, there may be a considerable saving in clerical time.

Items should be standardized before they are classified. They should be classified before they are symbolized. Therefore, complete classifications of accounts, equipment and materials, products and functions, should be available before the development of a mnemonic symbol system is attempted.

There are two types of mnemonic symbol system—the limited root and the unlimited root system. In the limited root system the number of basic or root classifications are limited to twenty-three letters of the alphabet, as the letters I, O, and Q are not used. This system is the better known and is the one which will be described.

**The Construction of a Mnemonic Symbol System.** In constructing a mnemonic symbol system, each letter in a symbol indicates a function or a characteristic. The first letter in the symbol indicates the subject of the symbol and is called the root letter. In other words, it indicates a general classification. For instance, the letter S is used in almost all mnemonic classifications as the root letter to indicate the general classification of stores accounts. The other letters in the symbol qualify the meaning of the root letter. In the case of steel stores, the symbol SS has been used in most cases, the root letter S indicating stores accounts, and the second letter S indicating that the particular classification is that of steel stores. A number preceding a letter in the symbol indicates a modification of the characteristic or function which that letter represents. Where there are a large number of items to symbolize, the symbol may be expanded to such lengths that it becomes cumbersome if we attempt to indicate each particular item by a mnemonic letter. In such cases, serial numbers preceding the last letter of the symbol may be used to indicate particular items. While this practice holds the length of the symbol within convenient limits, it is open to the objection that it lessens to some extent the mnemonic value of the symbol. In working up symbols, the letters I, O, and Q are not used, for the reason that they are easily confused with the numerals one and zero, particularly when the symbol is written on a typewriter.[1] In some cases the letter Z is not used, as it is difficult to write clearly.

The first step in the construction of the symbol system after the

[1] Furthermore, some of the older foremen, using the old-fashioned script, may make a "Q" which looks like the Numeral 2.

items have been standardized and classified, is to set up the base sheet. The letters of the alphabet, with the exception of I, O, and Q, are listed vertically. Opposite the letter with which it begins is placed each of the basic classifications. When more than one classification appears opposite a letter, the name of the classification should be changed to some other, equally descriptive, which begins with another letter that has not already been allotted to a classification. Where this is not possible, some letter which has the dominant sound of the word may be used. In some cases, the last letter of the word has been found to be sufficiently mnemonic. When none of these choices are possible, it is better to select some letter that has no relation to the name of the class. The fact that the letter has been selected on a principle which is exactly opposite to the mnemonic principle will tend to impress the meaning of the letter on the mind of the user. As stated previously, the base classification should conform to the classification of accounts. In some cases, it may be necessary to change this classification somewhat for purposes of symbolization. The following example is taken in part from the base classification used by a large concern manufacturing munitions:

*Base Classification Sheet*

| | |
|---|---|
| *Expense accounts* | A—(A)uxiliary expense accounts. |
| | B—(B)usiness expense. |
| | C—(C)ommercial expense. |
| | D—(D)epartmental and other factory expense. |
| | F— |
| *Product accounts* | G—(G)uns and other firearms. |
| | H— |
| | J— |
| | K—(C)artridge products. |
| | L— |
| | M—(M)iscellaneous products not elsewhere classified. |
| | N— |
| | P— |
| | R— |
| | S—(S)tores. |
| | T— |
| | U— |
| | V—Sal(V)age products. |
| | W— |
| | X—Fi(X)tures, tools, jigs, gauges and similar equipment. |
| | Y—Machiner(Y) and equipment. |
| | Z—Real estate, buildings, and building equipment. |

The letters in parentheses are those which have been selected as root letters, in most cases because of their mnemonic value. The base sheet has only been reproduced sufficiently to illustrate the principle of its development. The first classification is for the accounts of the service departments. To illustrate, the AP accounts might be used to control the expense of operating the power department. Business Expense includes all of the expenses of the general administrative organization. Commercial Expense includes the various accounts of the sales organization. Departmental Expense includes the expense accounts of the directly productive factory departments. The classifications from G to W, inclusive, are product accounts, with the exception of S, which is reserved for stores. Those from X to Z, inclusive, are fixed asset accounts.

The next step is to take each of the general classifications in the base sheet and develop the symbols for the sub-classifications under them. The procedure is the same as before. Lay out an alphabet for the sub-classification and write the various designations for the sub-classes opposite those letters which suggest them. To illustrate, the first sub-classifications of factory expense might be built up as follows:

*D—(D)epartmental and Other Factory Expense*

D-A—
B—Brass foundry and rolling mill.
C—Cannon case shops.
D—
E—
F—Factory office.
G—Gun department shops.
H—
J—
K—Cartridge department shops.
L—
M—Machine shop.
N—

D-P—
R—
S—
T—Tool department.
U—
V—
W—
X—
Y—
Z—

The "D" accounts are used to control the expense of directly productive departments. All items of shop expense which cannot be charged directly to the product are charged into one of these accounts, such as the salaries and wages of foremen and machine adjusters in directly productive shops.

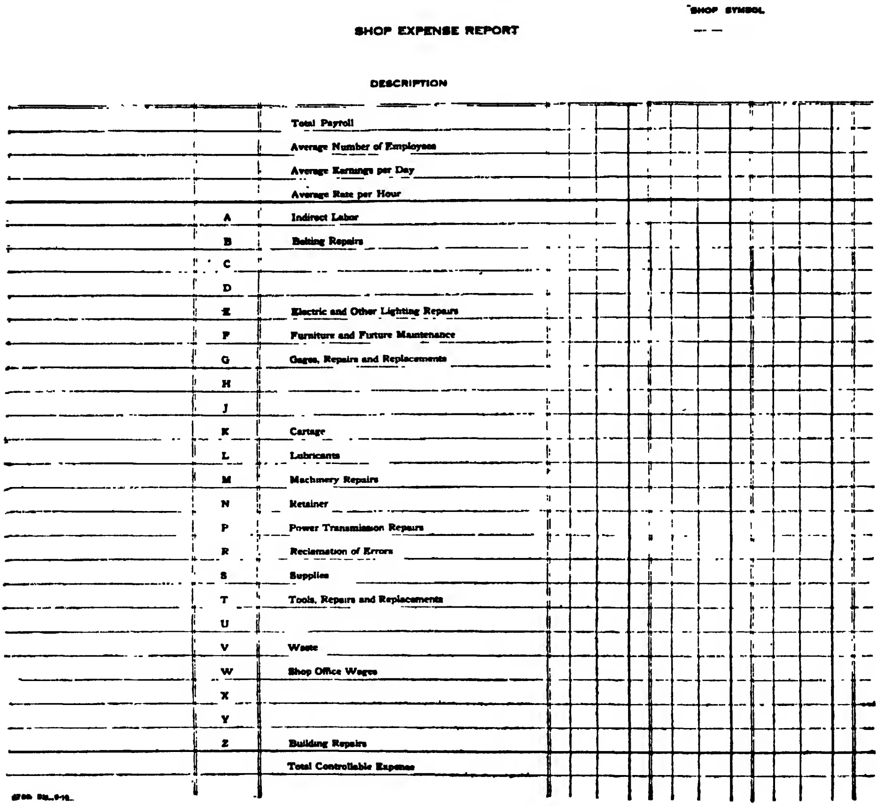
Each department may have a number of shops. These shops are numbered serially. The serial number of the shop precedes the department letter. The symbol for machine shop number three then would be D3M. To throw all of the expense of operating the shop under this symbol may not be sufficient for purposes of control. If this is

the case, a shop expense classification sheet must be made. This might be developed as follows:

*DM—Machine Shop Expense Accounts*

DM-A—
B—Belting repairs.
C—
D—
E—Electrical repairs and lighting expense.
F—
G—
H—
J—
K—
L—Lubricants, cutting and cooling fluids.

DM-M—
N—Retainer time.
P—Payroll.
R—Repair work and scrap.
S—Shop supplies not otherwise provided for.
T—Tools and repairs.
U—
V—
W—Waste, cotton.
X—
Y—
Z—



SHOP SYMBOL

SHOP EXPENSE REPORT

| | DESCRIPTION |
|---|---|
| | Total Payroll |
| | Average Number of Employees |
| | Average Earnings per Day |
| | Average Rate per Hour |
| A | Indirect Labor |
| B | Belting Repairs |
| C | |
| D | |
| E | Electric and Other Lighting Repairs |
| F | Furniture and Future Maintenance |
| G | Gages, Repairs and Replacements |
| H | |
| J | |
| K | Cartage |
| L | Lubricants |
| M | Machinery Repairs |
| N | Retainer |
| P | Power Transmission Repairs |
| R | Reclamation of Errors |
| S | Supplies |
| T | Tools, Repairs and Replacements |
| U | |
| V | Waste |
| W | Shop Office Wages |
| X | |
| Y | |
| Z | Building Repairs |
| | Total Controllable Expense |

*Courtesy—Winchester Repeating Arms Co.*

FIG. 81

A Shop Expense Report

In shop D3M, it is necessary to have certain belts repaired. This work will be done by a belt-fixer from the maintenance department. His time will be charged to the shop expense account D3MB. Similarly, work may not come through to the shop as planned. Certain men are temporarily idle. They will be given operation tickets made out to the expense symbol D3MN. The time during which they are idle will be charged to this expense account. In some cases monthly expense statements are given to each foreman to assist him in controlling the indirect expense of his shop. An example is shown in Fig. 81.

The product symbols identify the work-in-process accounts and the worked material inventory accounts. For this reason they are of interest to the production and materials division as well as to the accounting department. The letters E to W, inclusive, in the base alphabet, with the exception of S, are reserved for product symbols. The symbols for the various products are built up exactly as illustrated previously.

*G—Gun Products*

G-A—
B—
C—Carbines.
D—
E—
F—
G—
H—
J—
K—
L—
M—Machine guns.

G-N—
P—Pistols, revolvers, and other side arms.
R—Rifles.
S—Shotguns.
T—
U—
V—
W—
X—
Y—
Z—

There may be a number of different models of each class of gun products, so it is necessary to modify the sub-classification to show the particular model. A rifle designed in 1917 might be known as the model 17 rifle. The symbol for this rifle would logically be G17R. However, the rifle is composed of a number of assemblies, which in turn are made up from a number of parts. This is also true of the other gun products. Therefore it will be necessary to set up sub-classifications for each of the classes of gun products. The next sub-classification might be made up with regard to assemblies as shown below:

*GR—Rifle Assemblies*

GR-A—
B—Barrel assembly.
C—
D—

GR-N—
P—
R—Receiver assembly.
S—Stock assembly.

E— T—
F— U—
G— V—
H— W—
J— X—
K— Y—
L— Z—
M—Miscellaneous parts.

The actual list of assemblies would be much greater than the above list and would be different for each class of gun product. While a logical system for identifying our various gun products has been developed, it is still necessary, for purposes of cost and production control, to have some method of identifying the individual parts which make up these assemblies. This can be done by modifying the assembly letter by a serial number for the part. A production sub-order bearing the symbol G17R3R would indicate that it was for part number three of the receiver assembly of the model 17 rifle. It is obvious that a short concise symbol of this kind can be entered on a production paper or record more quickly and accurately than a long written description. Furthermore, new employees will more quickly become familiar with their duties if the papers which they handle are identified mnemonically by some such logical symbol system. It should be noted that each position in the mnemonic symbol has a definite meaning. The first letter in the symbol always indicates the base classification. The second letter always indicates a particular classification and modifies the root letter. A number in the symbol always modifies the letter which it precedes. In the above example, the letter G indicates that the symbol is a product symbol and that the product is a gun. If the letter G were the third letter in the symbol it might indicate something entirely different, but in the position which it holds it can indicate only one thing—that we are dealing with a gun product.

In order to link up the symbols more closely with the production and costs system, it is often provided that a number following the symbol will indicate the lot or order number. A number preceding the symbol will indicate the operation being performed. Thus, if the symbol on the production sub-order were 12-G17R3R-105, it would refer to operation No. 12 on part No. 3 of the receiver assembly of the model 17 rifle, and would show that the particular lot of rifles is being manufactured on order No. 105. When the part is completely manufactured and put into stores on a worked-materials credit slip, the quantity completed will be charged on to the stores ledger sheet bearing the symbol G17R3R. Operation tickets and material requisitions received by the cost department in the course of the manufacture

of the part were charged on to the cost card bearing the symbol G17R-105. If it were desired to segregate the labor cost of operation No. 12 on the order for the part, the complete symbol could be used. Thus a flexible system is provided which links together the work of the production division, the materials division, the accounting department, and the cost department.

Another large group of symbols is the classified stores symbols. This group does not include worked materials and finished product, although they may be carried regularly in stores and ledger sheets may be provided for them in the stores ledgers. The following is an example of a stores classification. These symbols appear on all stores requisitions and credit slips. They facilitate the work of the stores clerks in identifying the required materials, and the ledger clerks in posting to the stores ledgers and sorting for posting to the controlling accounts. They should appear on purchase requisitions and purchase orders for material.

*Classified Stores (Thompson and Lichtner)*[1]

S-A—Office supplies.
B—Brass and brass products including pipe and fitting.
C—Coal, coke, and other fuels.
D—Wood and wood products.
E—Electrical supplies.
F—Fastenings, bolts, nuts, nails, screws, etc.
G—Gaskets and packing.
H—Hangers, stands, boxes, bushings, pulleys, and clutches.
J—Gears made of all materials.
K—Chemicals and pigments.
L—Liquids, lubricants, oils, gasoline, and paints.
M—Machine and engine parts for boiler power and water supply.
N—Metals not otherwise classified as babbitt, lead, zinc, etc.
P—Pipe, pipe fitting, and tubing made from cast iron, wrought iron, and steel.
R—Rubber scrap.
S—Steel, wrought or cast iron, and products made chiefly from the same.
T—Tools, implements, and supplies.
U—Building materials such as cement, quartz, sand, and brick.
V—Abrasive, emery wheels, grindstones, etc.
W—Wearing apparel.
X—Stores not otherwise classified.
Y—Fibrous and textile materials such as belts and sundries, hose, rope, and twine.
Z—Special parts and supplies for equipment.

The main classifications are divided and subdivided to show sub-classifications and individual items much in the same manner as in the case of worked materials.[2]

[1] *Management's Handbook*, p. 470.

[2] The above classification is based largely on the kind and character of material. Other classifications are based on the use of the material and as a result are quite different.

Usually, the general ledgers carry a number of controlling accounts for the important classes of materials. For instance, all of the above main classifications might be controlling accounts. The sheets in the stores ledgers for the individual items are grouped together according to these controlling accounts. In other words, the sheets for the various items of office supplies regularly carried in stores would be grouped together under the symbol SA in the order of their mnemonic symbols. In this manner, mnemonic symbols facilitate the work of posting.

The classifications which have been given are intended only as illustrations of the method of constructing mnemonic symbols. In developing a symbol system, each plant must do its own work of standardizing and classifying materials, products and accounts, and must develop a system which will fit its particular needs.

In most plants, the introduction of a mnemonic symbol system would benefit the organization. It provides a common language which assists in coordinating the various factors in industrial organization and management. In identifying the various instruments which they use in the performance and control of their functions, all departments use the same system of symbols. The collection of information relating to the conduct of the business is facilitated for the reason that the chance of error in transmitting the information is reduced, a superior method of identification makes it easier to transfer or record the information, and a logical system for filing the information is provided. Perhaps the greatest benefit that the mnemonic system confers is that it leads the company to standardize and classify the various factors in its business. Many industrial management specialists feel that lack of adequate standards is one of the greatest causes of waste in industry.

## CHAPTER XVIII

## THE CONTROL OF MATERIALS—STORES AND SALVAGE

**The Stores Organization.** The stores organization is the physical custodian of all inventories not charged directly to some department or order. Every piece of material which comes into the plant should pass through the stores organization. It is responsible for the safety of this material until it is released to some other department on proper authority. Inasmuch as the value of the material inventories may run into very considerable sums of money, the importance of the proper organization of stores is readily apparent.

In the illustrative organization which has been set up, there are four departments in the stores organization—(1) the receiving department, (2) the stores department, (3) internal transportation, and (4) the shipping department. In a large corporation the stores organization would be under the supervision of a stores superintendent, reporting to the materials manager.

**The Receiving Department.** All purchased material which is received into the plant must pass through the receiving department. The department must see that all goods received are inspected to determine whether or not they conform to the specifications in the purchase contract. It must render a report of the extent to which the shipment meets the requirements of the purchase order. Copies of the report are sent to all departments which are concerned in the receipt of the shipment. Usually these departments are the purchasing department, the balance-of-stores department, the laboratory, and the storeroom. The report is usually called the material-received sheet. The character of the information contained on it is shown on the form in Fig. 83.

The nature of the inspection which is made usually is determined by the instructions in the receiving copy of the purchase order. All material which is received is not sent to the laboratory. In many cases a visual inspection of the material and a count of the quantity received is all that is necessary. On the other hand, it may be necessary to send samples of such materials as coal and steel to the laboratory for tests which the receiving inspectors are not competent to make or for which they have no equipment. In large plants, these inspectors may be under an inspection foreman who reports to the chief inspector.

The receiving department is under the supervision of an executive

THE WHITE MOTOR COMPANY

RECEIVING COPY OF PURCHASE ORDER

# THE WHITE MOTOR COMPANY

## WHITE TRUCKS AND BUSSES

842 EAST 79TH STREET
CLEVELAND, OHIO, U. S. A.

Order No. R J-36593

| | |
|---|---|
| Applies on Contract | |
| Dated | Date |
| Buyer | Req. |
| Stenographer | Deliver to Dept |
| To | Charge Account |
| Address | Dept. Issuing |

In consideration of within order, you guarantee that the sale or use of the parts herein ordered do not infringe any United States patent, and covenant to defend every suit which may be brought against us, our successors or assigns, or any party selling or using any product of ours for any alleged infringement of any patent by reason of the sale or use of said parts, and to pay all expenses and fees of counsel which shall be incurred in and about defending, and all costs, damages and profits recoverable in every such suit; and you further agree not to sell or otherwise dispose of parts similar to the parts herein ordered and bearing a trade mark of The White Motor Company to others than The White Motor Company, unless its permission is first obtained in writing.

Blue prints, designs and specifications, furnished by The White Motor Company in connection with its purchase orders, are understood to be the property of The White Motor Company and shall be returned with all copies thereof to The White Motor Company on demand. They shall not be used for making up any other orders than from The White Motor Company unless its permission is first obtained in writing.

Material purchased hereunder which does not meet our inspection requirements shall be rejected and the vendor hereby agrees such rejected material shall not be sold or offered for sale to anyone except that after reworking it may be again offered to The White Motor Company for inspection and purchase.

*Ship via* *F O B* *Terms*

| QUANTITY | PART No. | ARTICLE AND DESCRIPTION | PRICE |
|---|---|---|---|
| | | | |

DATE TO SHIP: PROMISED

E. N. O.

SEE SPECIFICATION

| Number Received | Total | Receiving Memo. | Date | Number Received | Total | Receiving Memo. | Date | Number Received | Total | Receiving Memo. | Date |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

*Courtesy—The White Motor Co.*

FIG. 82

RECEIVING DEPARTMENTS COPY OF THE PURCHASE ORDER

usually known as the receiving clerk. Considerable responsibility attaches to his position, as he is responsible for the safety of all materials after the carrier has delivered them, up to the time that they are turned over to the storeroom. The shipment may not conform to the purchase order, but if it is damaged or stolen while it is in the custody of the receiving department, the company must pay for it.

The position of the receiving department in the organization is controversial. In many cases it is placed under the purchasing department, for the reason that the work of receiving is closely connected with the work of purchasing. The receiving of the material is one

INSPECTION DEPT.

RECEIVING DEPARTMENT REPORT
THE ROBBINS & MYERS CO.—SPRINGFIELD, OHIO.

RECEIVED FROM ..........................................

ADDRESS .......................................... DATE

| DATE SHIPPED | CARRIER | PRO. NO. | DELIVERED TO | CHARGED TO |
|---|---|---|---|---|
| NO. PACKAGES OR CRATES | GROSS WEIGHT | CHARGES | | |

| PUR. ORDER NO. | QUANTITY | DRAWING NO. AND DESCRIPTION OF MATERIAL | REJECTED |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

AMOUNT O. K. ............ INSPECTED BY ............ RECEIVED BY ............

AMOUNT REJECTED ............ REMARKS ............

*Courtesy—The Robbins & Myers Co.*

FIG. 83
INSPECTION COPY OF RECEIVING DEPARTMENT REPORT

of the final steps in the routine of procurement by purchase. However, it is also a step, preliminary to placing the material in stores. Furthermore, the receiving department is concerned with the physical handling rather than the clerical handling of materials. For this reason it has been placed under the stores department.

**The Shipping Department.** The functions of the shipping department are to see that the finished product is properly packed for shipment, that it is shipped in accordance with the instructions given by the traffic section, that the right goods in the proper quantities are shipped to the consignee on the date indicated by the sales department.

The condition in which the goods are received, obviously has much to do with the customer's satisfaction. Therefore, the design of the container in which the goods are shipped, as well as the packing of

the goods, is important. The shipping department often has an opportunity to save much money by developing low cost containers which will land the product at its destination in good condition. Furthermore, the promptness with which the department handles shipping orders is an important factor in building up the good will of customers.

Usually the shipping department operates on shipping orders received from the sales department. Fig. 84 shows a shipping order.

Form G-1 2B 10M Sets 7 27

WHOLESALE

WHITE SEWING MACHINE CO.

Cleveland, Ohio

refer to
Order No.

Order Dated

Received

Shipped

Ship to

Town

Charge

Filled by ____________

Checked by ____________

Postage ____________

Insurance ________ Tickets

All orders, contracts and agreements solicited by traveling salesmen, or otherwise, must be wholly in writing, and can only bind this Company when accepted by it at this office.

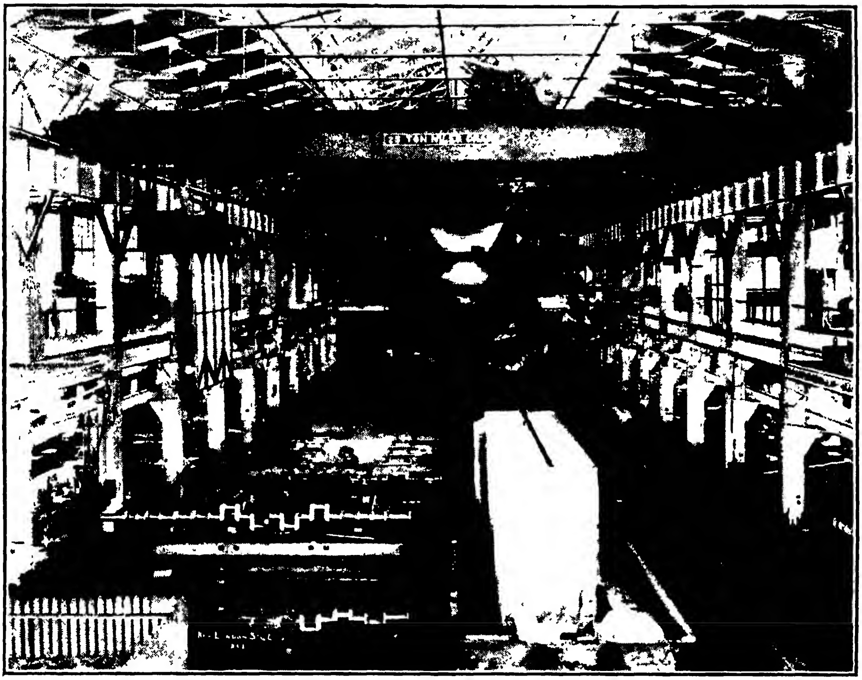
| Via | Your Order No. | Terms |
|---|---|---|

| Quantity | No. | DESCRIPTION | Price | Amount |
|---|---|---|---|---|

*Courtesy—The White Sewing Machine Corp.*

FIG. 84
SHIPPING DEPARTMENTS COPY OF SALES ORDER

On receipt of these orders, the department may withdraw the goods from finished stores or it may receive them directly from the assembly floor, depending on the nature of the company's operations. The goods are crated and shipped as directed. Consequently, the shipping department is often under the sales organization. There are also certain advantages in better production control which may make it advisable to place it under the production organization. As in the case of the receiving department, the shipping department is a plant department. It is chiefly concerned with the handling of the finished product.



*Courtesy—Niles-Bement-Pond Co.*

PLATE 18

A TRAVELLING CRANE

*Courtesy—Chain Belt Co.*

PLATE 19
A POWER CONVEYOR

Therefore, the department has been placed under the stores organization. It is supervised by an executive usually called the shipping clerk. Under him there may be a force of clerks, loading gang bosses, laborers, carpenters, etc.

As previously stated, the finished product sometimes goes directly from the last operation on the assembly floor to the shipping floor. However, all finished product should pass through finished stores on a paper transaction, if not physically, for accounting purposes. Therefore, it will be necessary for the shipping department to originate a requisition for finished stores, although the goods may be received directly from a department under the production organization.

**WHITE SEWING MACHINE CO.**

Daily Report of ______

| Trans. No. | NAME | ADDRESS | [illegible] | Car | [illegible] | [illegible] | [illegible] | [illegible] | Cabinets | [illegible] | [illegible] | [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |

*Courtesy -The White Sewing Machine Corp.*

FIG. 85

A Daily Report of Shipments

**The Stores Department.** The storeroom is responsible for the safety, care, and issue of all materials and supplies not in process or in use. It operates directly under the supervision of a storekeeper. Under him are a number of stores clerks and laborers.

**The Storeroom Layout.** The layout of the storeroom directly affects the work of handling the material inventories. When possible, each item which is carried regularly in stores should be located with regard to its ultimate destination. It should be stored as closely as is practicable to the department which uses it the most, in order to facilitate quick deliveries to the department and shorten the distance that the material must be moved through the plant. It may be necessary to modify this practice with regard for the efficient handling of materials or the grouping of materials of a similar kind or use. For this reason,

sub-storerooms for particular items of material often are established near departments which use them constantly in large quantities. In the example of the munitions plant, the copper and spelter used in the making of brass would not be stored in the general storeroom, but in a sub-storeroom in or near the brass foundry. Not only the quantity and the rate of use, but also the character of the material, affect its location in stores. Coal usually is piled in yards, conveniently located to the power plant. The high explosives used in the making of cartridges are stored underground at some distance from the plant to reduce the danger of disastrous explosions. The relation between the amount of storage space available and the quantity and bulk of the material also will affect its location. The type of conveying equipment may be a factor. These and similar factors affect the economy of storing materials.

In laying out the storeroom, the main aisles should run in the general direction of the flow of material into the plant in order to minimize congestion. They should be large enough to permit the free movement of trucks into and out of the storeroom. Usually, they are at least ten feet wide. The side aisles leading from the main aisles should be sufficiently wide to permit the passing of two trucks. The distance between the bin stacks should be enough for a man and a truck.

**Storage Bins.** Bins for storing material are made of wood or steel. In the majority of modern storeroom installations, knock-down sheet-steel bins are used for the reason that they are more flexible with regard to possible variations in bin sizes. Flexibility is desirable for the reason that it may be necessary to change the layout of the storeroom as the business expands and the need for storage space increases or requirements change. The standard sheet-steel bin has a depth of two feet. It is so constructed that it can be assembled in varying heights and widths of bins to suit the requirements of the materials to be stored. As far as possible, bin sizes should be standardized in order to facilitate the shifting of stocks when necessary. The determination of standard bin sizes in some cases may be affected by the nature of the units of issue which have been selected. Plate 17 shows steel storeroom bins.

When wood bins are used, the bin sizes should be standardized as before. If possible, the bins should be so designed that they will nest within one another. This type of wood bin is commonly used for storing tools in shop tool cages.

**Symbolizing Storage Spaces.** After the storeroom has been laid out, the various bins and storage spaces should be symbolized in order that the material may be located and the requisitions filled easily and

quickly. There are two methods which may be used. The bins and storage spaces may be numbered according to their location in the storeroom. Starting with the stacks nearest the entrance to the storeroom, the stacks may be numbered in numerical sequence. The stacks to the left of the main aisle may be the odd and those to the right the even numbered stacks. In addition, each section in the stack is lettered in alphabetical sequence and each tier is numbered. Therefore if the symbol 25A5 appears on a requisition in the space for stores location, it indicates that the bin for the material is in stack 25, section A, tier 5. The second method of symbolizing the bins and storage spaces is to use the mnemonic symbols of the materials. Under this system all bins for materials of the same basic classification would be grouped together in the same part of the storeroom in the order of their mnemonic symbols. The objection to this system is that it is not sufficiently flexible. The various items are located not with regard to the point where they are most frequently used or with regard to the relative number of requisitions for them which must be filled in the course of the day, but with regard to inventory-controlling accounts. Such a method will not meet the needs of the storeroom.

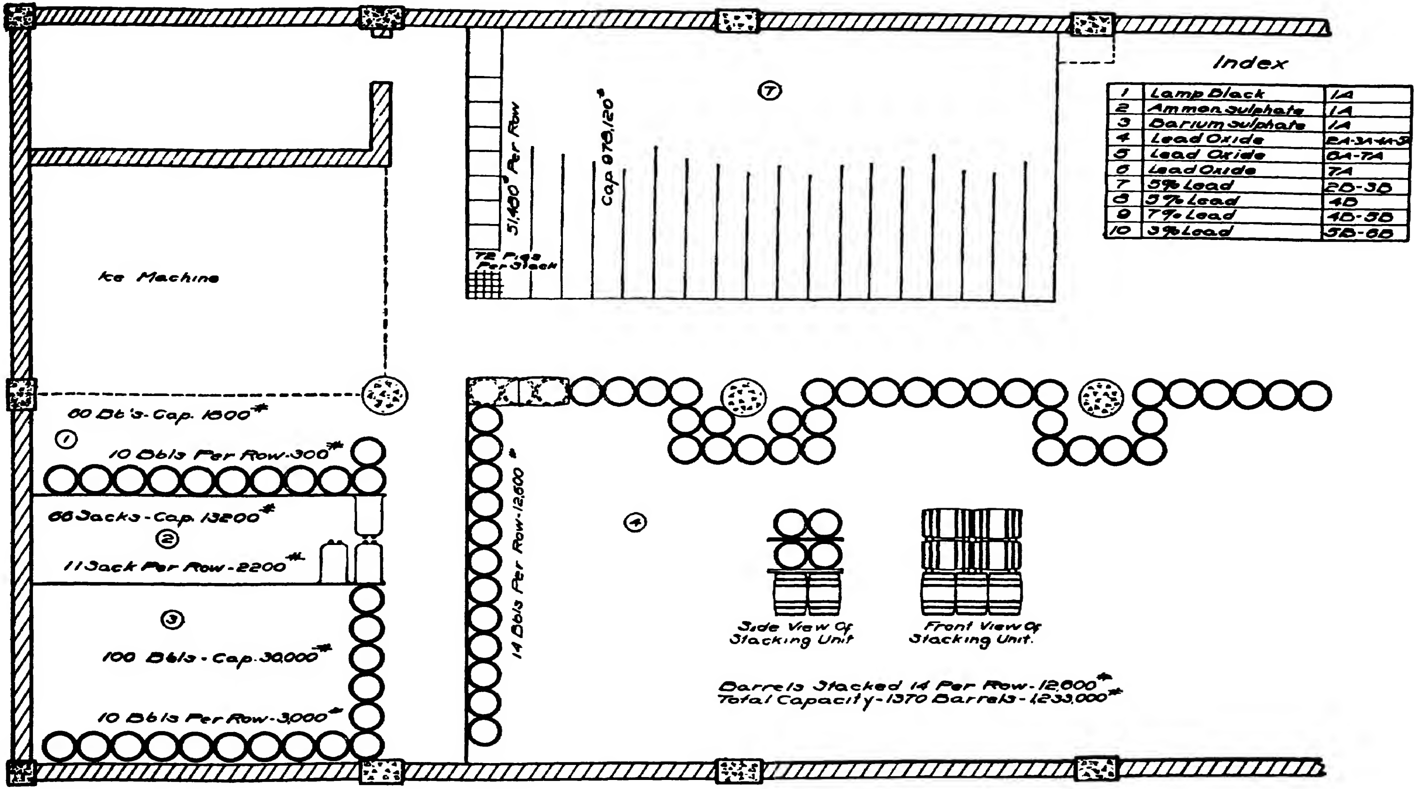
There are certain materials which cannot be stored in bins, but must be piled in open storage spaces. Lumber, various kinds of pig metal, sacks of loose material, barreled materials, are examples of items which are piled. While the nature and quantity of the material to be piled will affect the size of the storage space for the material, such space should be standardized as far as possible. To illustrate, tote boxes for transporting material should be standardized so that a certain number of a given size can be piled on the platform of a lift truck. Open storage spaces should be marked off by lines, painted on the floor, so that a certain number of lift platforms can be conveniently stored in each space. These storage spaces also should be symbolized. Usually the standard storage spaces or storage bays are indicated by painted signs hung from the storeroom ceiling, bearing the symbol of the storage space. This method makes it very easy to locate any particular space.

**Stowing Materials.** Even the piling of material is not left to the chance fancy of a stores clerk. In the modern storeroom, the best method of piling each item of material is determined and adopted as standard. It is the usual practice to start piling at the back left-hand corner of the storage space and work forward, as the stores clerks or laborers can work to better advantage. In some cases the items are piled in multiples of five for convenience in taking inventory. When new material is received, the old stock is piled in front or on top of the new stock in order that it may be used first. With some materials

it may make no difference, but with others it may be necessary to prevent loss from deterioration. Where materials are packaged before piling, they are wrapped securely and clearly labeled, so that the kind and quantity of material in the package can be easily identified. In the storeroom, order is essential. Most plants have too little available storage space rather than too much. Unless there is a place for everything and everything is in its place, confusion and loss are bound to occur which will hamper the work of the storeroom. The mark of the well-managed storeroom is order and neatness. While there is much more to the technique of piling materials than has been indicated, the preceding discussion should make clear the necessity for having standard methods of piling.

When the layout has been completed, stores locations assigned and methods of storing or piling worked out, it is advisable to make a permanent record. Drawing and tracings of the final layout are made. Blue prints are taken and filed in the storeroom. Fig. 86 shows a location diagram. In addition there is often a visible index file in the storeroom which shows for each item carried in stores, its name, symbol, stores location, maximum and minimum, and any other information which the storekeeper may need regularly. Such a file often is necessary when a requisition is presented at the storeroom window which does not bear the symbol or stores location of the item.

**Protecting the Stock Against Shortages.** It has been noted previously that checks have been provided in the stores ledgers to prevent the available stock of any given material from becoming dangerously low. This is the function of the minimum ordering point. However, there is always the danger that a ledger clerk may fail to note that the available stock of a given item has reached this point, and as a result production may be delayed because of a shortage. For this reason, certain checks usually are maintained in the storeroom. One of these methods is the use of what is known as the physical minimum. There are two methods for bin storage—the Barth double-bin system and the Gantt physical minimum. Under the Barth system there are two bins for each item carried in stores. These bins, of course, are side by side. In one bin is the old shipment from which material is being used. In the other is placed the new shipment. When the stores clerk reaches the bottom of one bin, he notifies the balance-of-stores department, which places an order for another shipment of material if it has not already done so as a result of the operation of the minimum ordering point. Material is now withdrawn from the second bin as needed. When the new shipment arrives, it is put into the first bin, but it is not used until the second bin is exhausted. In this manner, dangerous




*Courtesy—John A. Fisher.*

FIG. 86

PART OF A STORES LOCATION DIAGRAM

depletion of stock is avoided and old stock is used up before new stock is issued.

The Gantt system uses a single bin. The minimum ordering quantity is physically separated from the rest of the material. If the material is small screws and the minimum is 500, this quantity may be tied up in a sack and placed at the bottom of the bin. The rest of the material received in the shipment is piled on top of it. When the

STOCK ROOM ____________ DRAWING NO. ____

AISLE ____________

INVENTORIED ____

| DATE | RECEIVED | | WITHDRAWN | | BALANCE | RESERVE STOCK |
|---|---|---|---|---|---|---|
| | TRANS. NO | AMOUNT | ORDER NO. | AMOUNT | | |

*Courtesy—The Robbins & Myers Co.*

FIG. 87
A Bin Tag

supply has been exhausted down to the sack, the balance-of-stores department is notified and a new order for the screws is placed. The 500 screws in the sack should last until the new shipment is received. The Gantt method is the more economical in so far as the use of storage space is concerned.

The bin tag is a useful device which also checks the condition of inventories. On every bin and storage space there must be some card or tag which will identify the material in it. In the case of bins, there

is usually a clip beside each bin in which is placed the identification tag, showing the name and symbol of the material in the bin. In the case of open storage, the identification tag often is hung on a standard in front of the storage space. The bin tag provides a convenient means of identification, and in addition a record of the amounts placed in and withdrawn from the bin or storage place. The tag shown in Fig. 87 indicates the information usually given by it. When a physical inventory of stores is taken, the amount on hand is entered on the bin tag for each item. As requisitions for a given item are received and material is removed from the bin, the date of issue and the amount issued are entered on the bin tag. The amount is deducted from the previous amount on hand, so that at any time the bin tag should show the amount in the bin. Similarly, when the material is received into stores and placed in the bin, the amount is added to the tag. When the amount on hand reaches the minimum ordering quantity or the tag is used up, the quantity in the bin is inventoried, a new tag is made out with the inventory quantity, and the old tag is sent through to the balance-of-stores department as a check on the accuracy of the stores ledgers. This method has the advantage that the stocks of material are continually being inventoried, and each time when there are the fewest pieces to be counted. It eliminates the necessity of an expensive annual or semiannual inventory of stores, to a large extent.

In some plants the accuracy of the stores ledgers is checked by a patrolling inventory. There are certain men in the storeroom whose duty is to inventory continuously the stock on hand. Periodically, each item of material is counted and a record of the count is sent to the balance-of-stores department. This removes the necessity for and is usually more accurate than an annual inventory. In most cases the annual inventory is conducted under pressure and is notoriously inaccurate.

**Surplus Stock and Changes in Location.** It sometimes happens that there is surplus stock which cannot be handled in the regular bin or storage space. In such cases, the surplus must be located out of the way in a temporary location. A surplus-stock tag is made out for each surplus lot. This tag shows (1) material name and description, (2) material symbol, (3) normal location, (4) temporary location, and (5) quantity in the lot. The surplus-stock tag is hung under the bin tag. If there is more than one tag, usually they are hung in sequence of dates when the lots were received.

The demands for space are constantly changing. Some change in engineering specifications may mean that considerably more of a given item must be carried than formerly. If the present bin space is not sufficient to care for the new requirements, a new location must be

assigned. When this is done, a change of location notice should be hung on the old bin. This prevents confusion and reduces the delay in filling requisitions, due to the fact that the location symbol has not yet been changed on the stores ledgers or for other reasons.[1] The change of location notice shows (1) material name and description, (2) material symbol, (3) units and quantity moved, (4) moved from (5) moved to, and (6) approval of storekeeper. A copy of this tag should be used to change the visible index record in the storeroom and should then be sent through to the balance-of-stores department to correct the location records in the stores ledgers.

**Material Handling.** During the past few years, material handling has developed rapidly as an important phase of industrial management. Today there are many concerns which specialize in the manufacture of industrial material-handling equipment. The importance of proper material-handling is indicated by the fact that a considerable part of the cost of manufacturing is the cost of handling raw, worked, and finished materials, in a great many instances. In many plants the cost of production is too high because of excessive or unnecessary handling, due to the failure to use labor-saving material-handling equipment, the proper selection of such equipment, or the improper routing of material.

Material-handling equipment may reduce costs because of some or all of the following savings: (1) less labor required in moving material, (2) a more rapid turnover of inventories, (3) less congestion of work-in-process in the shop, (4) greater per capita production, (5) fewer interferences to production due to lack of materials, (6) the release of valuable working space, and (7) more accurate production control.

With properly selected material-handling equipment, a laborer often can handle more material, with no more physical effort and perhaps to greater advantage, particularly when there is danger that raw materials or work-in-process may be spoiled or damaged in handling. Not only can a greater quantity of material be handled with the same number or fewer laborers, but the speed at which it can be handled usually is much greater. Consequently, there is a greater rate of turnover of inventories. As a result, the shop can be supplied adequately with raw and worked material, with a smaller investment in inventories. Capital is released for other purposes and interest charges are reduced. In many cases this will result in large savings. The speed with which inventories are handled may be increased further by a more direct routing of materials, made possible by the use of

[1] A change of location notice also may be necessary when a change in specifications renders the use of a given material obsolete, resulting in its transfer to salvage stores.

properly selected equipment. Very often the congestion of work-in-process in the shop is reduced. A smoother, steadier flow of materials, under more certain control, makes practicable smaller banks of work ahead of each workman. Furthermore, with many types of equipment, materials can be handled overhead to good advantage. As a result, not only the movement of work is facilitated, but the workman is less cramped for space in which to operate his machine. The result often is increased per capita production. The movement of materials usually is under better control, assuring a steady, continuous flow of work to the workman. There is less idle time while the workman is waiting for materials. Inasmuch as the hourly cost of a machine often is greater than the workman's hourly rate, idle time is expensive. If it is possible to maintain smaller banks of work-in-process ahead of each workman, much valuable factory space may be released. It can be used to give a more open, lighter, and more attractive appearance to the shop, making it more truly "a good place to work," or by rearranging present equipment it may be possible to place additional equipment, thereby increasing productive capacity without the necessity of building additional space. Finally, the more accurate and speedier movement of materials usually makes possible more accurate production control, itself an important factor in low-cost production. In many cases, it may make possible better service for the customer. The extent and kind of savings which material-handling equipment can make depend largely on the character of the production problems. In general, the possible savings in a jobbing concern are less than in a concern manufacturing a standard product in quantities.

Until recent years, the introduction of material-handling equipment has not progressed so rapidly as it should. Although the wastes from improper material handling are real, it is difficult to place one's finger on them definitely. In most plants they are inextricably mixed up in the plant overhead expense. Furthermore, the first cost of handling equipment, in some cases, is rather high. Even when handling equipment is installed, satisfactory results are not always obtained, for the reason that it may not be well selected or designed for the conditions which it must meet. This may be due to the fact that insufficient study has been given to the problem, which in turn may be due to a lack of realization of its importance. Sometimes it is due to a lack of proper engineering guidance.

There are various types and kinds of material-handling equipment. Some are intended to handle loose or bulk materials, while others handle individual items or groups of individual items. Some are intended to give continuous delivery of the particular item which it is

designed to handle, while others are designed for noncontinuous delivery. In the selection of equipment its mobility may be a factor. Some types are portable. Some are self-propelled. Many types have no mobility, being operated from a permanently fixed position.

*Management's Handbook* gives a classification of handling equipment from which the following is adapted.[1]

*Material Handling Equipment*

(1) Hoisting Machinery.
- (a) Cranes of various types.
- (b) Hoists.
- (c) Cable and tramways.
- (d) Excavating equipment.

(2) Package-handling Equipment.
- (a) Belt conveyors.
- (b) Gravity conveyors.
- (c) Chutes.

(3) Conveyors for Loose Materials.
- (a) Skip hoists.
- (b) Screw conveyors.
- (c) Continuous bucket conveyors.
- (d) Gravity conveyors.

(4) Elevators.

(5) Trackless Transportation.
- (a) Hand trucks.
- (b) Lift trucks.
- (c) Storage-battery trucks.
- (d) Trailer cars.

(6) Industrial Rail Transportation.
- (a) Locomotives.
- (b) Cable cars.
- (c) Gravity systems.
- (d) Hand-propelled cars.

The above classification is considerably abridged. Space will not permit more than a few examples of some of the more important types.

Traveling cranes are used to transport heavy loads over considerable areas. They are adapted to the movement of heavy or bulk materials in storage yards or in large shops. Plate 18 is an example. They are frequently used for transporting work in heavy metal-working establishments. The movement of the crane is directed by an operator in the cab. The crane moves on tracks laid over the supporting columns and the trolley carrying the hoisting drum moves on rails across the crane. In addition, there are monorail chain hoists, hand-operated traveling cranes, and other devices for the overhead handling of materials.

Conveyor systems are another common means of transporting materials. Some are power driven, while others operate by gravity. The

[1] See *Management's Handbook*, p.746

slat conveyor shown in Plate 19 is one example of many types of power conveyors. The gravity conveyor consists of an inclined way, constructed either of polished wood or of a metal frame carrying rollers, over which the material slides or rolls to its destination. The slope of the conveyor must be adjusted so that the material does not attain too great speed. A gravity conveyor is shown in Plate 20.

A great many kinds of trucks are in use. Some are hand-operated, while others are power-driven. Such equipment as the hand truck and the storage-battery truck are familiar to everyone. The elevator truck, such as is shown in Plate 21, is a convenient device for tiering materials in the storeroom. It consists of a movable platform attached to an elevating column. The platform can be raised to a height of about six feet and material can be tiered easily to a height of about eight feet. The lift truck is so constructed that the platform on which the material is carried is not permanently attached to the truck. The truck is run under the platform, which is then raised clear of the floor. The platform with its load of material is hauled to its destination and left there. It can be unloaded at the convenience of the shop preparation man. The trucker is not kept waiting. Less time is lost in loading and unloading trucks. Empty platforms can be loaded and conveniently placed so that the trucker can pick them up with his lift truck when he comes along. The lift truck is a considerable advance over the hand truck. An example is shown in Plate 22.

There are many types of aërial or semiaërial transportation devices for handling materials. An interesting example is the tramrail. It consists of a system of rails suspended from the shop ceiling, on which ride power- or hand-operated carriers. Loads up to two tons can be transported easily and quickly to any part of the shop covered by the system. An application of the tramrail method is shown in Plate 23. Other examples are aërial tramways, skip hoists, and similar equipment.

Tractors and industrial locomotives are used extensively. They may be steam- or gas-operated. In some cases, electric tractors are used. This class of equipment is used to transport materials in storage yards or between buildings. Storage-battery tractors, equipped with trailer cars, are sometimes used for the transportation of materials within the plant.

In determining whether a piece of material-handling equipment is a good investment, the interest, depreciation, operating, and maintenance charges must be balanced against the savings previously indicated. It is the general practice to require that the equipment must pay for itself within one year. The materials-handling division of the American Society of Mechanical Engineers has worked out certain formulas

for computing the economics of labor-saving equipment, which are given below:[1]

$$Z = \frac{(S + T + U - E)X}{A + B + C + D}$$

$$Y = I(A + B + C + D), \text{ and}$$

$$V = [(S + T + U - E)X] - Y, \text{ in which}$$

A—Percentage allowance on investment.
B— " " for insurance taxes, etc.
C— " " " maintenance.
D— " " " depreciation and obsolescence.
E—Yearly cost of power, supplies, and other items which are consumed; total in dollars.
S—Yearly saving in direct cost of labor, in dollars.
T— " " " fixed charges, operating charges, or burden, in dollars.
U— " " or earning through increased production, in dollars.
X—Percentage of year during which the equipment will be employed.
I—Initial cost of the equipment.
Z—Maximum investment, in dollars, justified.
Y—Yearly cost to maintain ready for operation.
V—Yearly profit from the operation of the equipment.

**The Internal Transportation Section.** In some plants an organization is set up for the transportation of materials in the plant. Because its work is closely related to the movement of stores, it has been placed under the stores department in the illustrative organization which has been set up.

The movement of work within a department, in most cases, is left to the department preparation or move man. However, the internal transportation system may establish routes for the delivery of material between departments and buildings of the plant.

It is responsible for the proper utilization of all transportation equipment, the speedy and prompt movement of materials and work, and the giving of continuous and reliable transportation.

**The Salvage Department.** The functions of the salvage department are to reclaim, rework, and dispose of scrap and waste, and to reduce the amount of scrap and waste which is produced in the plant. The work of the department is partially a manufacturing problem and partially a stores problem. It has to do with the reworking of scrap and waste received from directly productive departments, the sale of scrap, waste, or reclaimed material and the returning to stores of reclaimed material which can be reissued to the shop.

By scrap is meant that product which has failed to pass inspection and which cannot be reworked in the shop to meet the inspection requirements. By waste is meant all other by-products of directly or

[1] See *Management's Handbook*, p. 747.

indirectly productive operations and materials no longer usable for their original purposes. Under these definitions, the steel scrap from punch-press operations would be classified as a waste product.

The salvage organization is usually under the supervision of a salvage supervisor or engineer. His characteristics are more nearly those of a manufacturing executive than those of any of his fellow executives in the materials division. For this reason, the salvage department is sometimes placed under the production organization. However, the department's work probably affects the materials division as much as if not more than it does the production organization, and for this reason it has been placed under the materials division. The salvage executive must have knowledge of the product and the processes in the plant. He must have had experience with salvage methods and equipment. He should have considerable mechanical ability, for the reason that often he is forced to devise his own meth-


FIG. 88
THE SALVAGE ORGANIZATION

ods for reclaiming materials. The salvage executive has charge of the sorting shop, the salvage shop, and the salvage-yard gang. The salvage organization is shown in Fig. 88.

All waste or scrap rejected by the inspectors is forwarded to the sorting shop, except worked material which the operator can reprocess on his own time. Such material is accompanied by a scrap tag or report. This scrap report indicates the nature of the item and the cause of the rejection. It credits the proper expense or work-in-process account and charges the proper scrap account. The manner in which this report is handled depends on the nature of the material which is scrapped and the manufacturing routine. Usually standard containers for various kinds of scrap and waste are conveniently located in each department. When these are filled, they are forwarded to the salvage department, accompanied by the scrap tag or scrap report. When the scrap is received by the sorting department, it is sorted according to its ultimate disposition, as far as possible. Some can be reclaimed and returned to stores. Some can be worked profit-

ably for sale. Some must be sold for whatever it will bring as junk. The sorting department should originate a report giving such information as (1) date, (2) item, (3) quantity scrapped, (4) cause of the rejection, (5) department in which the scrappage took place, and (6) the disposition of the material. One copy of the report should be sent to the engineering department in order that the process engineers may take whatever action may be necessary. One should go to the production manager, and one to the salvage executive. When the material has been sorted, it is either sent to the salvage yard to be stored pending sale, or to the salvage shop to be worked.

In recent years a great deal of equipment has been developed for the reclaiming or reworking of scrap and waste. In the case of sheet-

853C 50M

**SCRAP**

**Date........................191..**

**Credit.**
(PRODUCT SYMBOL)

**From ..**
(SHOP NAME AND SYMBOL)

**Article........................**

**Kind of Metal**

SIGNED..........
INSPECTOR

FIG. 89
A Scrap Tag

steel scrap, powerful machines have been developed for pressing and baling it in convenient form for sale. In large plants, the cost of the cotton waste used in cleaning up machines is sufficient to warrant the installation of centrifugal machines for reclaiming it. The oil is thrown off and saved and the waste is bleached and returned to stores. Automatic screw machines and other automatic machines using cutting oils are equipped with wells in which the oil is contained. Small pumps attached to the machine pump the oil to the point where it plays on the point of the cutting tool. After it has been used for a while, it becomes fouled and unfit for further use. It is then taken to the salvage department and reclaimed by filtering. Steel turnings are taken to the salvage department, sorted according to the kind of steel, stored in bins near the railroad siding, and sold.

The varied activities of the salvage department can save the com-

pany considerable sums of money in the course of a year. In 1925 the Hudson Motor Car Company saved more than $3,000,000 through the operations of its salvage department.[1]

One of the greatest fields for usefulness is in the reduction of waste in the plant. In cooperation with the engineering and inspection departments, the salvage department should maintain a constant study of the causes of waste and scrap in the factory. By suggestions regarding the design or jigs and fixtures or other manufacturing methods, and propaganda in the plant, it can do much to reduce this costly item of expense. Exhibits of plant waste and articles in the plant magazine pertaining to waste reduction are some of the propaganda methods which have been recommended by authorities on salvage methods.

[1] "U. S. Auto Industry Stresses Salvaging," by Philip S. Hanna, the *Wall Street Journal*, December 1, 1926.

# CHAPTER XIX

## SIMPLIFICATION AND STANDARDIZATION[1]

**Definitions.** Simplification is that policy of management which seeks to conduct all activities and perform all functions of an enterprise in the least elaborate manner consistent with any given purpose.

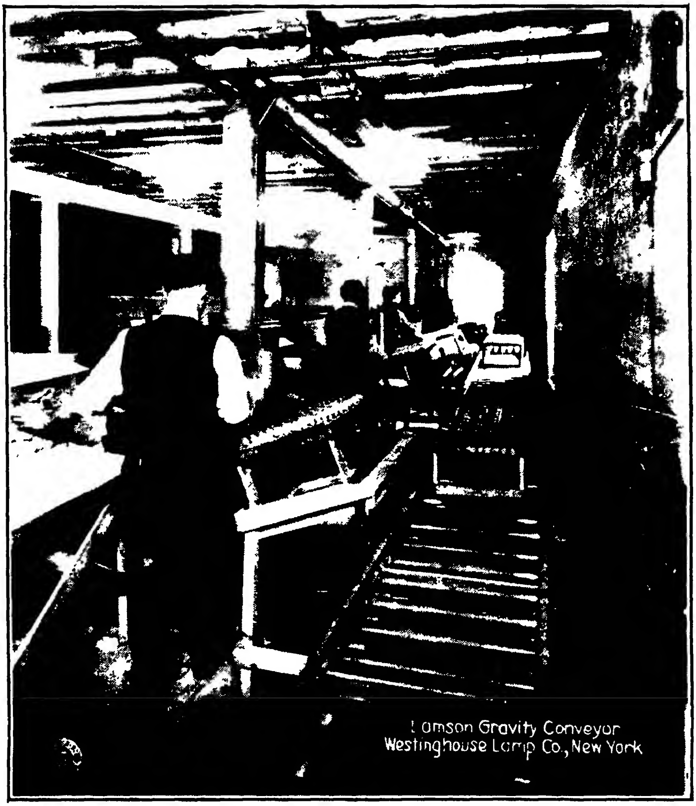
Standardization is the codification of the best current common practice.

**Simplification.** Simplification in industry refers largely to the elimination of excess variety. All individuals have some desire for means of expressing and emphasizing their individuality. In many cases sales managers, realizing this, have developed their sales methods primarily to exploit this desire. New models are introduced if any demand appears for them. Changes in existing models are made to suit the demands of customers. Models are altered frequently to play on this desire for distinctiveness. In many lines a great variety of styles are offered, many of which represent the whims and fancies of the public rather than any real need. In some cases 90 per cent of the sales are made with 10 or 15 per cent of the items in the total line. This means that there is a light demand and probably a slow turnover for the remaining 85 or 90 per cent of the items offered to the public. Simplification aims to eliminate, as far as possible, those items for which there is a light demand. This, together with the standardization of the remaining items, results in economies for the producer and savings for the public.

**The Movement Toward Simplification and Standardization.** The movement was started by the War Industries Board in 1917 and 1918. The board found that there was an unnecessary waste of capital, labor, and material due to unnecessary diversification. As the conservation of these factors in manufacturing was vital to the successful prosecution of the war, it commenced the study of the problem of simplification and standardization in industry, with notable results. To illustrate, the colors in men's hats were reduced from 100 to 9. The styles and types of rear gearings in tractors were reduced from 1,736 to 16.

Following the war, the movement was continued by the Department of Commerce, through its Division of Simplified Practice, The Chamber of Commerce of the United States, and the Federated En-

[1] The information in this chapter is taken largely from publications of the Bureau of Simplified Practice, U. S. Department of Commerce.




*y—The*

PLATE 20

A GRAVITY ROLLER CONVEYOR

gineering Societies. Under the leadership of the Division of Simplified Practice, the work has been extended to many fields of industry. In addition, the movement has received the active cooperation of many manufacturers' associations, which have realized the advantages of simplification and standardization partly as a result of the educational work which has been done, and partly as a result of the actual benefits gained from their war-time experiences in this field. For example, the National Retail Hardware Association passed a resolution in June, 1922, favoring the continuation of the program of standardization and simplification in the hardware field. A questionnaire to its members brought replies which were 98 per cent favorable.

**Two Kinds of Simplification and Standardization.** The work of simplification and standardization can be divided into two kinds—that within the industry and that within the company.

Simplification within the industry involves the cooperation of the principal producers in the industry. It may be realized generally that more types and styles of product are being offered to the public than are necessary. However, competition may prevent any one producer from reducing his line. If a customer cannot purchase a special style that he thinks he needs, he will purchase it from a competitor if possible. If he can get the special style from the competitor, probably he will place the remainder of his order for standard items with him also. Therefore there must be some agreement between the principal producers in the field before there can be any considerable curtailment of styles and models. In order to reduce the sizes of paving bricks from 66 sizes to 7, the Division of Simplified Practice had to arrange a joint meeting of the representatives of nine national organizations in the industry. Then considerable negotiation was necessary before a program of simplification was adopted.

The following are some of the advantages which are claimed for simplification and standardization within the industry:

(1) Less capital is tied up due to the greater ability to gauge inventory requirements.

(2) Lower production costs due to the fact that concentration on a smaller number of items results in larger manufacturing lots, with consequent economies due to better planning, the development of special equipment, greater opportunities for the improvement of processes, and other savings which come with longer runs and less idle equipment.

(3) Lower labor costs due to greater specialization, steadier production programs, and lower labor turnover. In many instances it is possible to use a lower class of labor.

(4) Prompt deliveries to customers. Simplification of the line of

products simplifies the production problem and reduces the number of broken promise dates.

(5) Usually the problem of sales and service is simplified, with greater satisfaction to the customer and the company.

Following are some of the results of simplification in various industries:

| | The Number of Items | |
|---|---|---|
| *Products* | *Before Simplification* | *After Simplification* |
| Malleable chain | 2,044 | 820 |
| Farm implements | 1,092 | 137 |
| Hammers, axes, etc | 2,752 | 761 |
| Laboratory apparatus | 2,800 | 1,400 |
| Pipe fittings | 17,000 | 610 |
| Stove parts | 2,982 | 364 |
| Pocket knives | 1,500 | 300 |

**Product Simplification and Standardization.** Simplification and standardization within the company, as the name indicates, has to do with the standardization and simplification of the line of products of a specific company. This development is possible even when there has been no simplification within the industry. Very often it will result in large savings to the company. Many machine elements have been standardized as a result of the work of the various engineering societies. In addition, it is often possible to standardize other elements of the product between various models, styles, and sizes. Three sizes of the same type of machine may use shafts which are identical in so far as their mechanical characteristics are concerned. They may differ somewhat in their dimensions, due to considerations of machine design. While it might result in some waste of material in the smaller sizes, it might be better, from the standpoint of manufacturing economy, to standardize on the larger size, if such a thing were mechanically possible, because it would then be possible to manufacture the shafts in larger quantities.

Most of the advantages which have been claimed for simplification and standardization within the industry will also result from the application of the same principles to the individual line.

**The Attitude of the Public.** It is not to be supposed that the public will immediately welcome simplification. Those persons who have become accustomed to using special goods will be loath to give them up. However, they can be educated to accept such changes because the changes usually result to their advantage. The consumer gets a better product, with better service, in more abundant supply, at less cost. The automobile field furnishes an excellent example of one in which the public gradually has come to recognize the advantages of the standard

product. This is so much the case that certain well-known automobile producers are featuring "no yearly models."

It must be admitted that there are some lines in which a certain amount of diversification is necessary. This is particularly true when the saleability of the article is largely dependent on style or the industry serves another which demands great diversification. Even when style is a large factor, it may be possible to attain some degree of simplification. The William Gilbert Clock Company reduced its line from 500 items to 75. The number of models carried at any one time is kept at this figure. The sales of the various models are constantly checked. When the sales of a given model begin to fall off, it is discontinued and a new model is substituted for it.

**The Objections to Standardization and Simplification.** Some of the usual objections to standardization and simplification are that it tends to automatize the worker, retards progress, destroys the advantage of secret methods, destroys initiative, limits markets, throttles foreign trade. In most cases they have little basis, being based on misconceptions of the problem. A discussion of them is beyond the limits of this book. In the opinion of most authorities on the subject, they are more than outweighed by the advantages to the manufacturer, the dealer, and the public which result from simplification and standardization.

## CHAPTER XX

## THE PERSONNEL ORGANIZATION

**The Development of Personnel Management.** The problems growing out of the development of modern industry have led to the introduction of a personnel department in a great many plants. The World War brought home to industry the fact that great losses occur as a result of the poor handling of labor problems. It was realized more than ever before that these problems must be solved by a specialized organization having in mind the point of view of the worker as well as that of the management; that they cannot be intrusted to the production executives because of their point of view and their inability to devote proper study to them because of the great demands which their regular duties make on their time. In some cases the personnel department has developed as the result of a realization by the management that industry has an obligation which is social as well as economic. To meet these obligations properly, some adequate channels of communication and contact with the employees are necessary. In this connection, the personnel department is a partial substitute for the man-to-man relations which formerly existed.

It is not intended to imply that the development of the personnel function in industry has been made subsequent to the World War entirely. Considerable progress was made during the ten years immediately preceding it. However, the development of the function received great impetus from the necessities of the war, and public interest in its development grew out of these necessities to a large extent.

**The Functions, Purposes and Work of the Personnel Department.** The more important functions of the modern personnel department are (1) to approximate the human relationships which existed prior to the advent of modern industrialism, (2) to secure fair treatment for the employee, and (3) to place labor relations on a business basis that will be fair to both the employer and the employee.

The community of interest between the employer and the employee was more apparent in the small industrial units which generally existed seventy-five years ago than it is in the large-scale industrial units of today. The employer and owner working at the bench with his men, as he often did, was brought into intimate contact with them. He knew them personally to the extent of being their confidant in many cases. On the other hand, the employees were not entirely unfamiliar

with the difficulties which their employer encountered in managing his shop and in getting sufficient business to keep it running. Today, the employees in our large factories have little conception of the work of production or management and almost no conception of industrial sales and financing. Because the employee in the small shop understood better the difficulties of his employer, a more sympathetic adjustment of any differences between them was possible. There are many small shops, enjoying harmonious labor relations today, in which this man-to-man contact exists. In our larger establishments, it is not possible to produce such conditions. It is one of the basic functions of the personnel department to approximate them, as far as possible, by developing better channels of communication between the management and the men, and better personnel relations.

In every factory, disagreements or misunderstandings will develop between executives and their employees. Most of these differences could be adjusted satisfactorily. It has not been long since a factory foreman was virtually a czar in his particular department. He hired and fired men at his discretion. In some cases he seemed to feel that the security of his position depended on the exercise of iron-handed discipline. Men have been discharged on insufficient cause merely to impress the working force with the foreman's authority. The fear of losing his job has been described by Whiting Williams as a powerful influence in the life of the worker. Theoretically, injustices to the worker can be corrected, in most plants, by appeal to the superintendent or some higher executive. It is not uncommon to hear a managing executive state that while his plant has no personnel department, the door of his office is always open to any employee in the plant. Actually, the employee must adjust his differences with his foreman or they are not adjusted. If he goes over the foreman's head, he may incur his enmity, to his own injury later. Furthermore, he is naturally diffident about presenting himself with some minor grievance at the office of an important executive. Yet these grievances, if allowed to go unattended, may grow into major grievances which may cause serious trouble. In any event, they are not conducive to good morale and high individual production. They seldom exist with the knowledge of the general management, but rather because the management cannot have an intimate knowledge of the details of shop management. It is therefore one of the functions of the personnel department to see that the individual employees get fair treatment. To insure this fair treatment, most concerns, having well-organized personnel departments, place the final authority for hiring and discharge in the personnel department.

It is not uncommon to find that a concern has a well-organized department for the procurement and control of materials, but rela-

tively little organization for the procurement and control of its labor inventories or the handling of labor problems within the plant. The cost of the capital which is tied up in the material inventories seems to be the more apparent. The cost of the capital which is tied up in the training of employees, the losses resulting from the poor selection of employees, improper placement and poor working conditions, and the cost of labor turn-over seem to be less apparent, although quite as real. Scott and Clothier have stated that there are three factors which should be considered before the worker can be placed to the best advantage. These factors are the capacities and interests of the worker and the opportunities afforded by the job.[1] The worker reacts to his surroundings and the opportunities afforded by his job. A worker placed in congenial surroundings and on work in which he is interested is entirely different from the same worker when the conditions are reversed. The difference is reflected in his production. Some of our modern organizations have developed methods for the more scientific selection of employees in advance of hiring. Many of them are attempting to develop and capitalize the interests of their employees. They are providing opportunities for advancement in earnings or position which stimulate these interests and make loyal, steadfast employees. They are beginning to show the same care in the procurement and maintenance of their labor inventories which they have previously shown in the procurement and maintenance of their material inventories. They are beginning to apply the methods of scientific analysis to the solution of their personnel problems.

**The Personnel Manager.** The personnel manager controls the performance of these delicate and complex functions. He should have well-developed social instincts. The opinion is growing that industry is under a certain social obligation to provide fair wages and reasonable working conditions, consistent with reasonable service for the public and a fair return for the stockholders. He should be endowed with tact, ability, and personality, inasmuch as his work is largely of a personal nature, involving the application and control of human rather than physical forces. Unless he is able to win the confidence of the plant personnel, his work will be seriously handicapped. In addition, a knowledge of men and an ability to size them up with approximate accuracy are part of his equipment.

With the human side of his job, there is a business and administrative side which is equally important. An industry is operated for profit. In the last analysis, the personnel manager must be able to show sufficient economic as well as social justification to warrant his continued existence in the organization. He must not only have a good

[1] *Personnel Management*, by Scott and Clothier, p. 15.

knowledge of the technique of personnel management, but he must also be able to transmute that knowledge into successful practice. He must be able to organize his department so that the day-to-day labor problems of the plant will be handled quickly and smoothly. Furthermore, the labor demands of the plant are constantly changing with the changes in business conditions. Often the personnel manager is in a position to exercise business foresight in the building up of his labor forces somewhat as the purchasing agent attempts to forecast changes

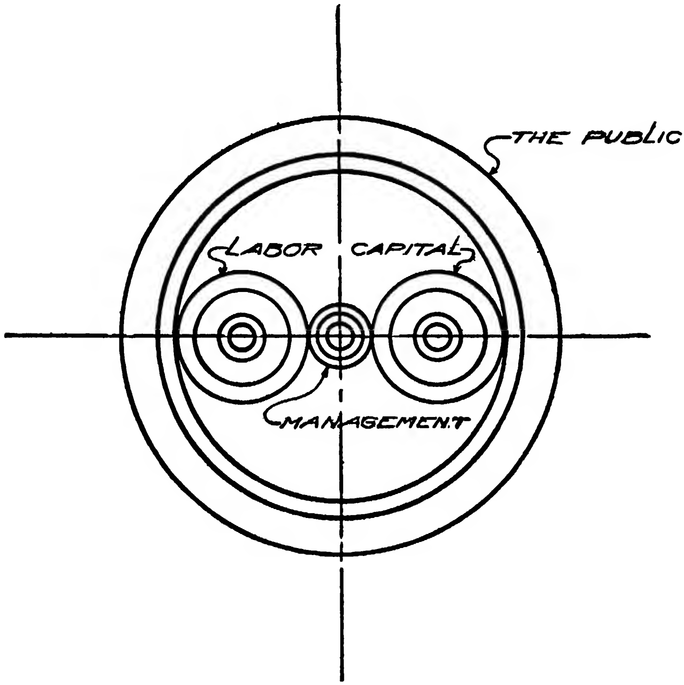



FIG. 90
THE GEAR TRAIN OF INDUSTRIAL RELATIONS

in production and prices in the procurement of materials. Some background of business and manufacturing experience should be part of the equipment of the industrial personnel manager.

In large concerns which are nationally prominent, the work of the personnel manager may require more than ordinary tact and ability. Reference has been made previously to the growing realization of the social obligations of industry. The relation of personnel management to industry and the public is illustrated by the diagram in Fig. 90, in which the two spur gears, capital and labor, run together through a pinion which may be termed management. The whole system runs

within an internal gear which may be likened to the public. To a considerable degree, good personnel management acts as a lubricant which facilitates the smooth operation of the gear train. In many instances, the application of this lubricant is a delicate operation which requires all of the tact and ability that the personnel manager possesses.

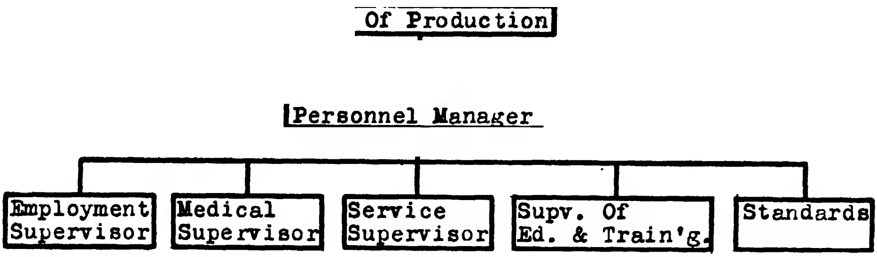



FIG. 91
THE PERSONNEL ORGANIZATION

**The Organization of the Personnel Department.** The personnel organization in Fig. 91 is intended to emphasize the major functions in personnel management. Such organizations will vary between plants, depending on the nature of the personnel problems. As shown, the organization operates under the direction of a personnel manager who reports to the vice-president in charge of production. The functions of the various departments or sections of the organization have been discussed previously in Chapter VI.

## CHAPTER XXI

## PERSONNEL CONTROL—THE WORK OF EMPLOYMENT

**Sources of Labor Supply.** In many respects, organized sources of labor supply are to the employment manager what the catalogue files are to the purchasing agent. When business is decreasing, the question of an adequate supply of labor may not be important. In periods of general business activity, when the production programs of most plants are expanding, the question of sources of labor supply may become very important. In general, they may be classified as external and internal.

The usual external sources of supply are those which are developed from contacts outside of the present organization, such as casual applicants, schools and colleges, records of old employees, public and private employment agencies, and labor centers not immediately contiguous to the plant. Various means of working these sources are used, such as personal interviews, labor scouts, advertising, or correspondence.

Many concerns depend largely on the casual applicants who come to the employment office. Such applicants receive interviews, their application blanks are received, and vacant positions filled as suitable applicants present themselves. If an applicant cannot be hired, his application blank may be filed as a possible future source of labor supply. This source is never entirely satisfactory. In times of general business activity, good employees have good jobs at satisfactory wages. In dull times, when good men may be out of work, the concern may be hard pressed to keep its own organization together. In times of extreme business activity, the employment office gets many applicants of the "floater" type who are decidedly unstable and unsatisfactory. Furthermore, records of previous applicants are only a fair source of supply because a large percentage of them will have jobs when work for which they are suited becomes available.

Schools and colleges are commonly used as sources of supply for technical and executive material which is suitable for further training with a view to filling executive positions ultimately.

Records of former employees sometimes prove to be valuable sources of supply. Many times employees are lost, due to unavoidable lay-offs or voluntary separations which cannot be prevented. Often both the character of their work and their relations with the company have been satisfactory. If they can be induced to return when suitable

work becomes available, the company will save money. In many cases they require little or no training before they reach their maximum production. They are familiar with the conditions under which they will work before they go on the job and as a result there is more assurance that they will remain with the company for a considerable time.

Foreign sources are those which are not contiguous to the plant and its immediate territory. During times of great industrial activity, industries sometimes import labor from considerable distances. During 1923 many concerns sent labor scouts into the South to bring North large numbers of unskilled negro laborers. The use of labor scouts is a phenomena which occurs when there is great competition for the available supplies of labor. Experience with this method is usually unsatisfactory. Often workers who accept the offers of the labor scout are floaters who are interested chiefly in getting transportation to the city in which the plant is located. Many times these men work for a few days and then quit without cause. Furthermore, once they are landed at their destination, it may be necessary to provide housing accommodations for them. Other industrial centers soon adopt similar methods and the net result may only be increased competition for available labor supplies and rapidly increasing wage rates. Advertising in foreign labor markets has much the same effect.

Except in the case of reputable employment agencies, specializing in the placement of trained workers, experiences with employment agencies are none too satisfactory.

Internal sources of labor supply are those which result from contacts within the present organization. When a job becomes vacant in the organization, it is better to fill it by promotion from some lower position, if possible, than to hire a new employee. Less training is required, there are fewer interruptions to the normal routine of production and management, and greater probability that the vacancy will be filled permanently. Some concerns have worked out definite promotion policies and logical lines of promotion.

In some instances concerns have adopted the policy of soliciting recommendations from their present employees. If the plant is a good place to work, the employees are anxious to get their friends into it. Such applicants come with a favorable impression of the plant. They already have friends among the workers. The chances that they will stay permanently are greater than they are in the case of the casual applicant. However, there is the danger that cliques may develop within the organization if too many friends and relatives get into the same department. The development of internal sources of supply

probably will pay greater dividends than external sources, in most cases.

**Personnel Office Layout.** Adequate facilities should be provided for handling the flow of applicants and the work of the personnel department. In many plants it will be found that the employment office is a small box-like place in a corner of the plant, adjacent to the street. The applicant, coming to a small window, is told that there is or is not work for him. There is nothing attractive about the employment office, and the first impressions of the applicant must be largely negative. The more progressive plants are providing cheerful and attractive employment offices in which there are waiting-rooms having adequate seating capacity for the accommodation of the applicants. The appli-

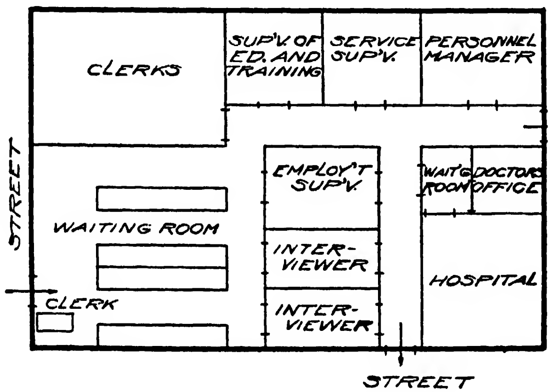



FIG. 92
A PERSONNEL OFFICE LAYOUT

cant for whom there is no work is more likely to leave with the impression that the plant is a good place to work than he is in the previous case. If at some future time he receives a card from the employment office stating that there is work available, there is greater probability that he will give it serious consideration.

In the layout in Fig. 92 the arrangement of the waiting-rooms, interviewers' offices, medical department, and the exit are such that the flow of applicants approximates a straight line as far as possible. Furthermore, the privacy of interviews is assured.

**Getting the Preliminary Employment Information.** When the applicant comes into the employment office, he should be handled quickly and effectively. In the layout in Fig. 92 a clerk seated at a desk near the entrance gives an application blank to the applicant. In some cases the latter fills out the blank. In the case of low-grade labor, the application blank may be filled out by the door clerk for the applicant.

The completed blanks are arranged on the clerk's desk in the order in which they are received. If the interviewers specialize in certain kinds of labor, they are further arranged in this manner. By the use of a buzzer or an interphone, the clerk is notified when a particular interviewer is at liberty. The next applicant is sent to the interviewer with his application blank.

**The Application Blank.** The purpose of the application blank is to bring out the more obvious characteristics of the applicant which affect his suitability for employment. The door clerk or the applicant fills out the blank with such information as does not require careful questioning and the exercise of judgment. The remaining information must be obtained by the interviewer. The nature of the information contained on the blank is indicated by the form in Fig. 93.

Many times the information on the application blank merely represents the personal prejudices of the particular employment manager. The usefulness of the information obtained should be tested by some correlation with the results of job analyses and the data obtained from the labor-turnover records.

The value of the files of application blanks as an aid in procuring labor depends on the availability of the information. Hundreds of blanks filed alphabetically according to the applicants' names are of little use, as it is necessary to go through all of them to find out which individuals have the desired qualities. A series of key numbers running across the top of the blank, representing labor classifications, on which distinctive flags can be placed, or cross filing by means of occupational cards, will increase the availability of the information greatly.

In a relatively short time many application blanks become practically valueless because the applicants have moved to other addresses, have obtained satisfactory employment elsewhere, or for other reasons. Some concerns periodically send cards to each person represented in their application files, requesting them to state whether they wish their applications continued. The cards of those individuals who do not reply within a given time are discarded.

**Determining Labor Requirements.** The interviewer should have complete information regarding vacancies, present or impending, in the departments for which he employs. There are two sources from which this information may be obtained. One is the labor program and the other is the labor requisition. Just as the sales program is broken down into units, parts, and materials to form the basis of the materials and production programs, so in some concerns the production program is analyzed to supply the basis for a labor program. The work of the personnel manager is facilitated if he can determine in

THE WHITE MOTOR COMPANY

## APPLICATION FOR POSITION

DATE ____________

NAME ____________

ADDRESS ____________ TELEPHONE No. ____________

I HEREBY APPLY FOR POSITION AS ____________

SALARY EXPECTED? ____________ SECOND CHOICE OF WORK? ____________

DID YOU EVER WORK HERE BEFORE? ____________ WHEN? ____________ UNDER WHOM? ____________

NAMES OF RELATIVES EMPLOYED HERE? ____________

HEIGHT? ____________ WEIGHT? ____________ MALE? ____________ FEMALE? ____________

ARE YOU SINGLE, MARRIED, WIDOWED OR DIVORCED? ____________ NUMBER OF DEPENDENTS? ____________

DO YOU RENT? ____________ BOARD? ____________ OWN HOME? ____________

BIRTH DATE? ____________ BIRTH PLACE ____________ NATIONALITY? ____________

DATE OF ARRIVAL IN U. S.? ____________ OF FIRST PAPERS? ____________ OF SECOND PAPERS? ____________

PHYSICAL DEFECTS, IF ANY? ____________

GIVE NAMES OF PROFESSIONAL, CIVIC, SOCIAL OR OTHER ORGANIZATIONS OF WHICH YOU ARE A MEMBER? ____________

### PREVIOUS POSITIONS (INCLUDING THIS COMPANY)

| NAME AND ADDRESS OF CONCERN OR PERSON | DATE FROM | DATE TO | SALARY | JUST WHAT DID YOU DO? | WHY DID YOU LEAVE? |
|---|---|---|---|---|---|
| LAST POSITION | | | | | |
| PREVIOUS POSITION | | | | | |
| NEXT PREVIOUS POSITION | | | | | |
| NEXT PREVIOUS POSITION | | | | | |
| NEXT PREVIOUS POSITION | | | | | |

*Courtesy—The White Motor Co.*

FIG. 93
AN APPLICATION BLANK—FRONT

L D 45

..................................19......

Department ..................................................

Job Name ..................................................

Requires:......Man. ....Girl......Boy Age............

For Day.................Night.............. .....Work

Day Work Rate..........: Average Piece Work Rate ..........

Will be on Piece Work After..........................Days

Average Overtime Per Week..........................Hours

Can Learn This Job in ... ............To................Days

Nature of Work: ..................................................

Repeated Operation.... ............ . Variety of Jobs.................

Heavy.................. Sitting ................ Fast................

Walking................ Standing ............. Clean .............

Bench ................. Acid ................ Gases .............

Wet.................... Hot ................. Boots .............

Wear Glasses ........... .................... ..................

Should: Read and Write English;................Blue Prints ................

Be...............Inches High; Weigh..............; And Have Experience

..................................................

..................................................

Help Required To Replace No. ..................................................

To Increase Force ..................................................

Approved ..................................Foreman

..................................Gen. Supt.

Filled..............................19...... No........................

*Courtesy—The Perfection Stove Co.*

FIG. 94

A LABOR REQUISITION

advance the probable demands of the plant to meet the production program for a given period. He may not be able to wait until these demands are actually made before commencing to build up the plant's labor forces.

In addition to the labor required to meet an expanding production program, the employment section is constantly engaged in hiring men to maintain the existing personnel. Regardless of the excellence of the company's labor relations, there will always be a certain number of separations from the payroll. As these vacancies occur, labor requisitions signed by the department head and approved by the proper authority should be forwarded to the employment office. On the authority furnished by these requisitions, the employment office procures the necessary labor. In some plants, the department head merely makes a telephone request for labor. However, the labor requisition gives formal authority for the addition of labor to the payroll and furnishes a basic record of the transaction. The information which usually appears on the labor requisition is indicated by the form in Fig. 94.

**The Labor Journal.** In large plants, a labor journal may be kept in which all hirings are recorded. When the labor requisitions are received in the employment office, they are first recorded in the journal and then forwarded to the proper interviewers, possibly with the job specifications attached. When the requisitions have been filled, they are routed back through the journal and the transaction is closed out as far as the employment office is concerned. Fig. 95 is an example of a labor journal.

At the end of the month the information in the journal can be summarized to give a report of hirings for the plant, by departments. More frequent reports on outstanding requisitions give a check on the efficiency with which they are being handled.

**The Interview.** Many concerns have a rule that every applicant may have an interview, whether or not there is a vacancy of the kind in which he is interested. They feel that a brusque statement to the effect that there is no work, or a sign hung on the door of the employment office to the same effect, is poor business. It is discouraging to tramp from one employment office to another to be met with this treatment at each place. If the applicant has an opportunity to talk for a moment with an employment executive and to leave his application blank, he is likely to go out with a friendly feeling toward the plant, which can be capitalized when later the plant may need men badly. Such application blanks may prove to be a valuable source of labor supply. During times of severe unemployment, it may be difficult, if

not impossible, to apply this principle completely, for the reason that the employment office probably will be flooded with applicants.

The man who interviews applicants has a job which requires tact and shrewd judgment. He must have a good personality, be sympathetic rather than brusque and repelling, in order that he may draw out the applicant and obtain all information which has any bearing on the applicant's suitability for the job in question. Some of this in-

THE PROCTER & GAMBLE CO
IVORYDALE PLANT

WEEKLY RECORD OF
REQUISITIONS FOR LABOR

*Courtesy—The Procter & Gamble Co.*

FIG. 95
A LABOR JOURNAL

formation may be of a personal nature. He should be a good judge of human nature to enable him to form some fairly accurate estimate of the extent to which certain intangible qualities, such as ambition, initiative, etc., are possessed by the applicant. It is difficult to measure such qualities objectively. Yet in many cases they directly affect the applicant's success on the job. The interviewer should be familiar with shop conditions, and in a general way with the requirements of the different types of work in the plant. His information probably will be reinforced by job specifications, giving detailed information about the

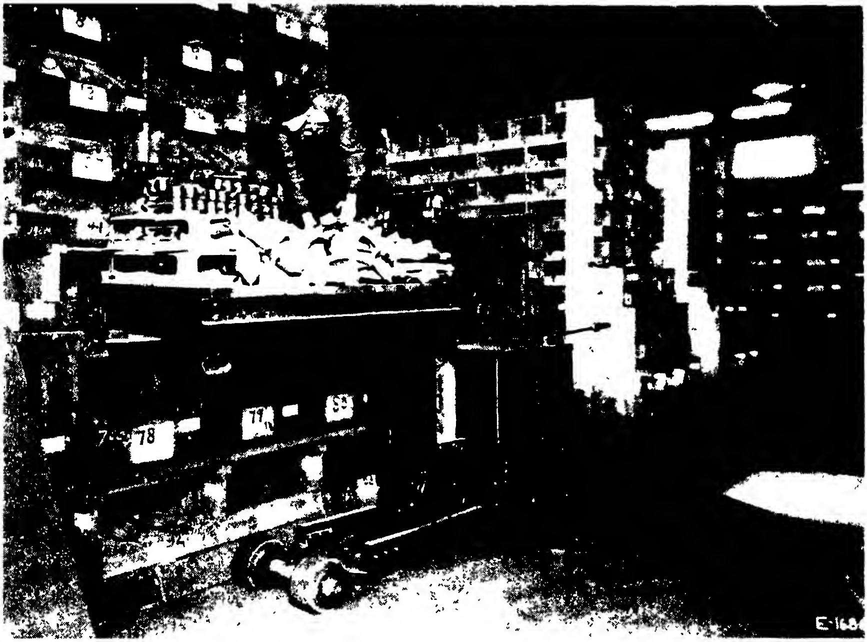



PLATE 21
An Elevator Truck

*Courtesy—The Stuebing-Cowan Co.*

PLATE 22
A LIFT TRUCK

labor conditions and requirements of specific jobs. Finally, the interviewer should be able to see the point of view of the worker as well as the management, to the end that he will not oversell the job to the applicant. If the interviewer overstates the conditions of work in order to recruit additional labor, a factor tending to cause dissatisfaction has been introduced. Some interviewers deliberately understate the de-

**The National Cash Register Co.**

Date ________________ 19 ______

Mr.

______________________ Dept. ______

This will introduce

Mr. ______________________

applicant for position of

Req. No. ______________ Dated ______

Manager Employment Department.

Fill in and return in sealed envelope by applicant.

Accepted at ____________ per hour / per week

To Report Date ____________ Hour ________ A. M. / P. M.

Position ______________________

Req. No. ____________ Date of Req. ____________

Remarks: ______________________

______________________

DEPT. HEAD.

Form 788—Printed in U.S.A.

*Courtesy—National Cash Register Co.*

FIG. 96

AN INTRODUCTION SLIP

sirability of the job to avoid this situation. If there is any one quality which the interviewer should have more than any other, possibly it is good personality. As previously noted, the production of the worker is affected by his interest in his job as well as his capacity to handle it. The determination of the worker's interests is a personal matter which depends on the interviewer's ability to gain the confidence of the applicant and to draw him out with regard to them.

**Getting the Foreman's Approval.** If the applicant appears to the interviewer to be suitable, he is usually sent, with an introduction slip, to the foreman or department head, who has the right of refusal. The introduction slip gives the man's name and the job for which he is applying. In some plants the employment department engages employees without previously consulting the men under whom they are to work. While the authority to hire rests in the employment manager in many of the more progressive organizations, there are many reasons why it is advisable to give the department head an opportunity to interview the men from whom he must get production, before they are hired. In the first place, this policy tends to strengthen the authority of the department head. In the second place, he is more familiar with the technique of the job which must be filled. His opinion as to the suitability of the applicant is correspondingly valuable. Finally, it is not entirely fair to hold an executive responsible for results from an organization, unless he has had some voice in the selection of that organization. If the department head is satisfied with the applicant, he notifies the interviewer to this effect by initialing the introduction slip. Otherwise the employment procedure stops at this point, unless the applicant is a suitable candidate for some other vacancy.

**The Physical Examination.** If the applicant is acceptable to the department head, the next step usually is a physical examination. The plant physician examines the applicant to determine his physical fitness for the job. In some cases the applicant may be suitable for employment, but because of certain physical disabilities may be limited by the plant physician to the performance of certain classes of work. Small plants often cannot afford the services of a full-time physician. In such cases it may be necessary to defer the examination of the applicant until such time as the physician is in attendance. Preferably there should be regular hours for examination each day. A summary of the examination is usually entered on a small card, or on the application blank, and returned with the applicant to the interviewer.

**Testing Capacity and Skill.** In a few of the more progressive plants, if the applicant's physical examination is satisfactory, he is given certain psychological or trade tests. If the applicant passes these tests, he is hired. As in the case of the physical examination, the results of the tests are entered on a card or on the application blank and returned to the interviewer with the applicant. Whether or not this step is performed depends on the policy and needs of the company. Most concerns do not give such tests, partly because they are still in the development stage.

**Hiring the Applicant.** If the applicant is satisfactory, an employee's history card and a notice of hiring are written. This notice, an ex-

ample of which is shown in Fig. 97, has the essential information relating to the job, the name of the employee, his starting rate, and other information which will permit the payroll department to record him properly on the payroll. In most cases, the notice of hiring is originated in triplicate. The original copy goes to the payroll department, the duplicate to the department head, and the triplicate is retained in the employment office. A fourth copy may be sent to the medical section for its information. If the employee does not go to work at once, the notice should show when he is expected to report.

**NOTICE OF EMPLOYMENT & FOREMAN'S RECEIPT**

MR.____________________ ______________19____

| Payroll Number | NAME | Occupation | Rate |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

RECEIVED THE PERSONS LISTED ABOVE, TOTALING______ON REQUISITION NO.______

TIME RECEIVED____________A. M. / P. M. SIGNED____________________

DEPT.________________

RETURN THIS SIGNED ORIGINAL TO EMPLOYMENT OFFICE BY ESCORT.

*Courtesy—The Procter & Gamble Co.*

FIG. 97

A NOTICE OF HIRING

The triplicate copy, with the requisition and the specification, is forwarded to the record clerks, who make the proper entries in the labor journal and file the papers.

**The Employee's History Card.** The employee's history card is the company's labor-asset record—the record of its human inventories. It is intended to give a brief but sufficiently complete history of the employee's connection with the company. As such it is a valuable aid in the work of promotion, wage adjustments, transfers, and the handling of the individual labor-relations problems which constantly arise. Like any other working record, the information which it contains should be current and in such shape that it is readily available. These records should be kept on file in the employment office. Figs. 98 and 99 are examples of a history card.

The principal groups of information which usually appear on the card are indicated on page 318.

EMPLOYEE'S HISTORY CARD

Trade ______________ Job No _____
Trade ______________ Job No _____

Employee's Name ____________________________________________

Address ____________________________________________________

____________________________________________________________

Age ___ Birthplace ______________________Citz.___ Tel.No. ___________

Physical Condition __________________________________________

In case Of Accident,Notify __________________________________

| Test | Date | Score |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

| Ratings | | | | | |
|---|---|---|---|---|---|
| Date | Grade | Date | Grade | Date | Grade |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Previous Experience

| Name And Address Of Employer | Dates | | Kind Of Work | Why Left |
|---|---|---|---|---|
| | From | To | | |
| | | | | |
| | | | | |
| | | | | |

Education And Training

| | |
|---|---|
| Gram.School 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 | H.School I - II - III - IV |
| College Years Course Degree | |

Company School Record

| Course No | Name | Date Compl | Grade | Attend | Remarks |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

FIG. 98
AN EMPLOYEE'S HISTORY CARD—FRONT

Promotions And Transfers

| Date | Dept | Job Name | Job No | Rate | Empl. No | Med. O.K. | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Attendance And Efficiency Record

| Year | Jan | | Feb | | Mar | | Apr | | May | | June | | July | | Aug | | Sept | | Oct | | Nov | | Dec | | Tot. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | E | A | E | A | E | A | E | A | E | A | E | A | E | A | E | A | E | A | E | A | E | A | E | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Relief Fund | | | Suggestions | | | |
|---|---|---|---|---|---|---|
| Date | Amt. | Remarks | Date | No. | Amt. | Remarks |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Other Information ______________________________

________________________________________

________________________________________

________________________________________

________________________________________

FIG. 99

An Employee's History Card—Back

1. General information.
   This includes information on the application blank which has permanent value, such as,
   (a) Name
   (b) Address
   (c) Race
   (d) Nationality
   (e) Marital status
   (f) Age, and similar information
2. Summary of the physical examination
3. Results of tests
4. Education and previous experience
5. Company record
   (a) Promotion and transfers
   (b) Company ratings
   (c) Suggestion record
   (d) Intramural social or athletic activities
   (e) Production or efficiency record
   (f) Attendance record

As in the case of the application blank, the availability of information is important. The same device, suggested to increase the availability of the information on the application blank, may be used with the employee's history card.

**Introducing the Worker to the Job.** The manner in which a new employee is placed on the job often is an important factor in determining the length of time that he stays with the company. In most plants, the employee is taken to his department by a messenger from the employment office. The messenger hands a memorandum or notice of hiring to the foreman and leaves the employee with him. The foreman takes the employee to the machine which he is to operate, gives him whatever instructions may be necessary, and tells him to go to work. The new employee is not acquainted with the men working around him. He has little knowledge of the company or its methods, except that which is necessary for the satisfactory performance of his work. He has little opportunity to become acquainted with the plant or its products. Under such conditions, he can hardly be expected to have more than ordinary interest in his job. His first impressions of his job and the plant are cold and colorless. Except for the occasional visits of the foreman for the purpose of supervising his work and giving such additional instruction as may be necessary, apparently he has been forgotten by the management. The new man misses his former familiar surroundings and is inclined to be hypercritical with regard to the conditions which he finds on his new job. He becomes dissatisfied easily and may quit before he has become accustomed to the new conditions. In most industries, the greatest turnover takes place among those employees who have been with the company less

than one year. Within this group the greatest turnover is among those who have been employed less than six months.

**Adjusting the New Employee.** A number of methods have been used to ease the new employee over the period when he is breaking in on the job and becoming acquainted. In some cases, a representative of the employment office, rather than a messenger boy, takes the employee to his department. He is introduced by this representative to the foreman and to the men on the machines near his own. During the first few weeks some one from the employment office may visit the department periodically and talk with the new employee to see whether or not he is making satisfactory progress and is satisfied with his work. As a result, the new employee is more likely to feel that he is something more than a productive unit in a large organization; that the company has a personal as well as a profit-making interest in its employees.

Some concerns use department personnel representatives or sponsors. These representatives are employees in the department who are picked for their understanding, judgment, and personality. In addition to their regular duties, they are expected to make the new employees feel at home. For this service they are paid something in addition to their regular rate of pay. They introduce the new man to the men in his department, acquaint him with the building, inform him of the customs of the shop, and make it as easy as possible for him to adjust himself to his new job and surroundings.

**The Book of Rules.** Most plans provide new employees with a book of rules stating employment regulations and the company's labor policy. In some cases it explains the aims and ideals of the company, with the object of arousing the employee's interest and creating a favorable first impression. The book may contain some discussion of the products and the methods which are used in manufacturing it. Some common topics treated in the rule book are:

(1) Standard hours of work.
(2) Holidays.
(3) Payment for overtime.
(4) Information regarding the employee's benefit association.
(5) Rules covering absence and tardiness.
(6) Information regarding educational opportunities in the plant.
(7) Rules governing quits and dismissals.
(8) General information regarding the product and the business.

In some cases the excellent policies stated in such booklets are not applied in actual practice. As a result, employees often are skeptical regarding the degree of sincerity in back of such statements, and give their booklets only a cursory examination before throwing them away.

Unless the policies are honestly conceived and applied, their statement in the book of rules may do more harm than good.

**Familiarizing the New Employee with the Plant and the Product.** One of the biggest problems in industry is the employee's lack of knowledge of the functions and duties of the different units of the organization and the various processes necessary to the manufacture of the product on which he works. The average employee has little knowledge of the operations which precede or follow his own. He is familiar only with that portion of the work which passes across his machine or work-place. With such a restricted view of his job, he can hardly be expected to have a real interest in it, except in so far as he is stimulated by some wage incentive. Under such conditions, almost any job becomes extremely monotonous. This is most serious in the case of the new employee who is easily dissatisfied with his conditions of work. To counteract this situation some concerns give lectures, illustrated with motion pictures, at which the new employees are shown the different operations and the relation of their work to the various production processes.

**The Responsibility of the Interviewer.** One of the best ways of introducing the new employee to the job is to thoroughly acquaint him with the conditions surrounding the job before he is hired. If he gains one impression of the job when he is hired and then finds that it is materially different when he is put to work, probably he will be dissatisfied. It requires only a few moments at the end of the interview to acquaint the applicant with the essential details regarding the conditions under which he must work.

# CHAPTER XXII

## PERSONNEL CONTROL—HEALTH CONTROL AND MEDICAL SUPERVISION

**The Scope of Medical and Health Work.** The medical section obviously is concerned with the practice of industrial medicine. Industrial medicine has been defined by the United States Public Health Service to be "the theory and practice of medicine applied to the purpose of preventing and alleviating sickness and injury among industrial workers in order that they may enjoy the benefits of continuous, productive employment." This definition takes in a broad field which is only partially covered by most concerns. The average employer is interested chiefly in preventing and reducing the losses which result from a poor selection of employees, from the standpoint of physical capacity, and from poor health conditions among the personnel of the plant.

**The Medical Section—an Aid to Production.** There are a number of ways in which the plant physician can aid production. He can see that the employees are suited physically to their work. Sometimes he can prevent injury to workers on operations where normally there are considerable health hazards. By controlling sanitary conditions within the plant he is able to safeguard health generally. He may be able to conduct studies of operations, in coöperation with the plant industrial engineers, which will reduce the effects of industrial fatigue. In general, his job is to keep the working force tuned to the highest pitch of physical efficiency. If his work is well done, the results are reflected in increased per capita production.

**The Examination of Applicants.** The purpose of the medical examination of applicants is to insure that the physical capacities of the applicant meet the requirements of the job, to guard against the introduction of any communicable diseases which might endanger the workers' health, and to record any compensable disabilities received on previous jobs in order that the company may be protected against claims under any existing state compensation laws or suits at common law. An example of a medical examination blank is shown in Figs. 100 and 101.

Sometimes the objection is raised against the medical examination of applicants that it is unfair to those workers who have disabilities for which they are not to blame; that if the practice became universal, certain workers might be forced to become public charges who might

Form A-302

Printed in U. S. A.

**PHYSICAL EXAMINATION RECORD,** **CITY**

Applicant to answer the following questions:

NAME NO. DEPT.

OCCUPATION

Age Single Married Wid. Dependents

Trade

Have you ever had an operation? For what?

What serious accidents or diseases have you had?

When were you last treated by a physician?

For what?

Are you in good health at present?

Are you ruptured? Do you wear glasses?

Have you been successfully vaccinated within the last five years?

Remarks:

Date Applicant's Signature

Physician's Remarks

(over)

*Courtesy—Procter & Gamble Co.*

FIG. 100

A PHYSICAL EXAMINATION RECORD—FRONT

Special attention should be given to physical condition of applicant to determine fitness for occupation assigned

Sex Height in. Weight lbs.

Vision Right Left

Hearing Right Left

General Appearance

Pulse full / strong / irregular

Temperature

Heart

Blood-pressure Systolic / Diastolic

Atheroma

Please note any characteristic marks that will identify applicant, such as moles, scars, crowned teeth, tattoo, etc.

Head

Ears

Teeth

Lungs

Skin

Abdomen

Inguinal Region

Extremities

Nervous System

Nose

Mouth

Tonsils

C. U. Organs

Liver

Stomach

Hernia

Rectum

Varicosities

Arches

Reflexes

Urinalysis Specific gravity Reaction Albumen Sugar

Is there any condition present that will require surgical correction?

Is there any condition present that will cause frequent temporary disability?

Do you recommend the applicant for employment?

Date Signature M. D.

*Courtesy—Procter & Gamble Co.*

FIG. 101

A PHYSICAL EXAMINATION RECORD—BACK

otherwise be able to support themselves. As a matter of fact, a very small percentage of applicants is refused employment because of physical disabilities. Most applicants either have no disabilities or are debarred only from specific classes of work. In any case, the applicant receives valuable information regarding his disability which may aid him to remove it. Obviously it would be most unwise to employ an applicant in the first stages of tuberculosis for a job in a grinding-room, where the air may be filled with fine emery dust. It may be

**PERFECTION STOVE COMPANY**
(INCORPORATED)

PHYSICIAN

THE FOLLOWING EMPLOYEES ARE REPORTED ABSENT FROM DUTY TODAY

| NAME | DEPT. | REASON FOR ABSENCE | ABSENT SINCE | REMARKS |
|---|---|---|---|---|
| | | | | |

*Courtesy—The Perfection Stove Co.*

FIG. 102
A Doctor's Report of Absentees

objected that the medical examination of applicants is an unwarranted interference with the personal affairs of the employee. While there is such interference, it cannot be called unwarranted, for the reason that an employee has no right to bring into the plant a communicable disease which may be a menace to the health of his fellow employees. With some jobs, lack of physical capacity may result in accidents, endangering the lives of other workmen. For the most part, an industry is better off without those who refuse to take the physical examination.

**The Medical Examination of Employees.** Some authorities have advocated the practice of periodically examining all employees in the

plant. At present this is not the general practice. An applicant may be in perfect health at the time of employment. Six months later his physical condition may have changed radically. This is particularly true when the job has considerable health hazards. Unless the medical department conducts periodic audits of the general health of the working force, it may not immediately be aware of such conditions. The relation between the health of the employee and his daily production is so direct that in some cases the medical department is furnished with a copy of the daily production record of each employee. In other cases, the production department sends to the medical department those employees whose production shows a tendency to fall off, unless there is some apparent reason for it which has nothing to do with the man's physical condition. If this policy is linked up with a policy of periodic health surveys, the physical efficiency of the working force can be maintained at a high state. Many concerns urge their employees to report any physical disabilities to the medical department as soon as they become apparent. In the majority of cases, the employees will not do so until the disability interferes seriously with their earning power. Sometimes, concerns which do not conduct periodic health surveys require that employees must receive a medical examination before they can be promoted or transferred to a new job, or before they can return to work after a period of illness. Measures such as these, combined with general health propaganda in the shop, pay for themselves by improving health and living conditions in the worker's homes, reducing the amount of tardiness and absence, systematically matching physical abilities with conditions on the job, all tending to increase per capita production.

**The Visiting Nurse.** A few plants employ visiting nurses in connection with employee health maintenance. Usually, the visiting nurse visits the home of the employee after he has been absent for a certain length of time to determine the cause of his absence, and in case of illness to give such advice as may be necessary. At other times the nurse is available to the employees or their families at their request. The services of the nurse should not be forced on the employees.

In addition to possessing skill in her profession, the visiting nurse should be tactful, should have a pleasing personality, and should be imbued with a genuine desire to be of service to the employees and their families. After she has gained the confidence of the employees, the nurse may be able to perform a number of services which are not strictly in the field of nursing, but which will tend to improve the standards of living of the employees. To illustrate, the visiting nurse may be asked to give advice in the making of family budgets, dietetics,

and the care of children as well as the care of the sick. The services of the nurse usually are free to the employees.

There is some danger that activities of this nature may become paternalistic. Except in the case of continued absence of the employee, the visiting nurse should not visit his home unless requested by him to do so. It is the responsibility of the medical department to sell the value of the nurse's services to the employees so that requests for these services will come from them spontaneously. Expenditures for the services of a visiting nurse are usually justified on the grounds that her work tends to improve the health and morale of the workers through improved home conditions, and as a result increase their regularity on the job and their productive efficiency.

**Plant Sanitation.** The use of health propaganda has been mentioned previously. An important field for the plant physician is plant sanitation. Not only should he constantly endeavor to educate the employee regarding matters of personal hygiene and general sanitation, but he should also endeavor to safeguard the health of the workers by inspecting periodically the sanitary conditions in the plant. In some cases this work may involve bacteriological examinations of drinking water, installations of sanitary drinking fountains, proper locker room and toilet facilities, the prevention of occupational diseases through the introduction of proper sanitary methods, the installation of sanitary shower and wash rooms, sewage and garbage disposal, the removal of dust and fumes and similar activities.

**Emergency Medical Service and First Aid.** In many modern factories the emergency medical service has had considerable development. The extent of this development depends on state requirements, the size of the company, the attitude of the management toward personnel work, the degree of hazard in the various occupations, and the relation of the company to the community. Almost all of our industrial states require some emergency medical service. In many cases, little more than first-aid kits, conveniently located, is required. The emergency service varies from this up to complete service in the plants of some of the larger corporations, such as the United States Steel Corporation, which maintains a number of completely equipped hospitals. One is shown in Plate 26. Those industries whose occupations are hazardous or whose products are such that they may carry the diseases of employees to the public usually spend relatively larger sums for medical and hospital service. Some large corporations located in small communities provide extensive medical service, partly because they dominate the social as well as the economic life of the community, which must look to the corporation for such service.

In connection with emergency medical service, the training of first-

aid crews may be a part of the work of the medical department. Where it has been formally organized, it may include training under the supervision of the company doctors, lectures, demonstrations and drills. Usually no employee can be appointed to a first-aid crew until the plant physician has certified that he is competent in such work. In order to stimulate interest, some companies hold annual competitive drills between their first-aid crews.

**The Cost of Medical Service.** Many concerns spend considerable sums for plant medical service. In some cases greater amounts must be expended than in others because the occupations are hazardous, the

FORM C-1087

NAME________________ DEPT.________ NO.________

| M | D | Y | H | INJURY OR ILLNESS | TREATMENT | BY WHOM | REMARKS | WORK | HOME | HOSP |
|---|---|---|---|---|---|---|---|---|---|---|

*Courtesy—Procter & Gamble Co.*

FIG. 103
EMPLOYEE'S HEALTH RECORD

men work long hours, the work is very monotonous, the nature of the industry is such that diseases of employees can be disseminated among the public by means of the product, or, as previously pointed out, the relation of the company to the community makes it advisable. To illustrate, the food and mining industries usually spend more for medical service than the average industry. The following figures give a comparison of the relative amounts expended by different industries for medical service. They are taken from the July, 1921, issue of the *Monthly Labor Review* of the U. S. Bureau of Labor Statistics. While the individual items probably do not accurately represent present expenditure, it is probable that the relation of these figures to one another is reasonably correct.

*Comparison of Medical Expenditures*

| *Industry* | *Number of employees* | *Annual cost per person* |
|---|---|---|
| Abrasive | 8,225 | $ 7.88 |
| Automobile | 32,212 | 5.68 |
| Boot and shoe | 15,189 | 7.75 |
| Chemicals | 21,080 | 6.38 |
| Clothing | 622 | 4.70 |
| Electrical | 101,272 | 3.15 |
| Food products | 31,489 | 8.40 |
| Foundry | 4,164 | 4.18 |
| Iron and steel | 105,263 | 4.10 |
| Metal manufacturing | 207,900 | 3.75 |
| Mining | 8,600 | 24.40 |
| Printing | 6,952 | 2.45 |
| Public utilities | 15,867 | 5.15 |
| Rubber | 40,688 | 5.41 |
| Smelting and refining | 87,932 | 8.41 |
| Textiles | 55,048 | 3.59 |
| Tobacco | 13,580 | 1.84 |
| Miscellaneous | 20,405 | 2.81 |

The number of employees refers to the number of employees in the establishments surveyed in each group. The average cost for all industries was stated to be $4.43.

While medical service is rarely given with the idea of making a profit, certain savings will result from it. The employee is returned to the job with a minimum loss of time. In many cases, compensation to injured employees or compensation insurance premiums are reduced. Regularity of attendance is increased. The generally higher level of health often results in increased per capita production.

# CHAPTER XXIII

## PERSONNEL CONTROL—EVALUATING THE JOB AND THE MAN

If maximum performance is to be obtained, there should be some reasonably accurate determination of the personnel requirements of a given job, the capacities of the man being considered for that job and the relation between the two. A number of instruments and methods have been developed for evaluating these factors, of which the more important are the job analysis, the rating scale and various objective tests of capacity.

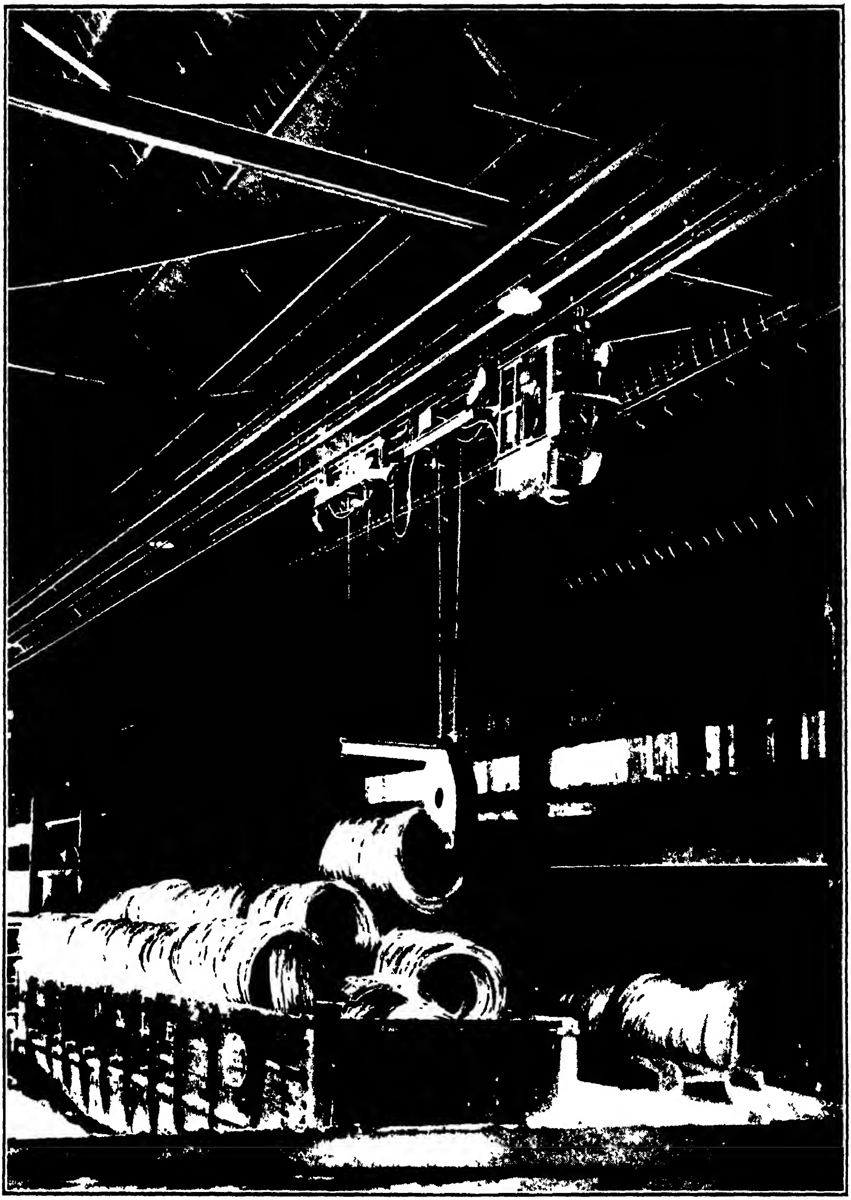
**Job Analysis.** A job may be defined as a work assignment involving operations which distinctly distinguish it from other work assignments. The job analysis is an analysis of the job and the conditions surrounding it, from the standpoint of personnel control. In this respect, it differs materially from a time study. Its purpose is to procure for the personnel department information regarding the job and the worker which will facilitate the work of employment, promotion, transfer, and training.

The information obtained by the job analysis may be divided into two classes:

(1) That which concerns the work.
- (a) Name of the job.
- (b) Job symbol.
- (c) Departments which have the job.
- (d) The nature of the work and the responsibilities involved.
- (e) Conditions surrounding the work, such as shift hours, speed, accuracy required, posture, monotony, health or other hazards, wage payment methods, starting rates, and similar information.

(2) That which concerns the worker.
- (a) Experience required.
- (b) Education required.
- (c) Physical requirements.
- (d) Language.
- (e) Personal characteristics.

**Methods of Making the Analysis.** Three methods which have been used in the making of job analyses are observation of the worker on the job, interviews with his superiors, and the use of questionnaires. Probably the best method is to send an analyst into the shop to determine by observation, the personnel elements which enter into each



*Courtesy—Cleveland Crane and Engineering Co.*

PLATE 23

A TRAMRAIL INSTALLATION

job. As in the case of time-study observations, the employee should be thoroughly informed regarding the purpose of the observation.

**Studying the Job and Collecting Data.** For each job, the analyst notes the general character of the work. He observes the employee at work to determine what he does and how he does it in order to determine the nature of the demands which the job makes on the employee. To illustrate, he may find that the work is very fine, requiring constant attention and causing considerable eye strain. As a result of his observations and conversations with the employee, he will work up considerable information regarding the job, similar to that previously mentioned.

After this study has been made, the information obtained should be checked by an interview with the foreman. The employee's idea of his job and the foreman's idea of it are not always the same. Furthermore, the foreman's opinion is not always correct. Quite often the worker, because of his closer contact with the job, may point out certain personnel elements entering into it which have not been appreciated by the foreman. Conversely, the foreman may point out certain angles of the job which are not apparent to the employee, for the reason that he is not looking at the job from an administrative standpoint. One of the problems of the analyst is to harmonize these different viewpoints and to determine what the personnel requirements of the job really are. In checking up these requirements, the analyst must bear in mind that the supply of labor fluctuates with business conditions and rarely is it possible to secure the ideal man for the job. Usually, the employment office must be content with something considerably less than the ideal. Therefore, he must determine what are the minimum qualifications for the job as well as what are the desirable qualifications.

In the shop, questionnaires are unsatisfactory. The questionnaire is likely to be inelastic. It is difficult to design one which will draw out all of the essential information concerning each job in the plant. In the second place, the average employee or shop executive will not take the necessary time to make out a questionnaire correctly. Furthermore, questionnaires are likely to interfere with production to a greater extent than the observational method. They may be made out incorrectly, due to the fact that shop workers usually have only a limited education, and may misinterpret various questions. Even when filled in properly, they are likely to be smudged with grease and dirt, making them illegible.

**Making the Data Comparable.** The comparability of job analysis information is important. To increase comparability and to facilitate the determination of the requirements of the job by the interviewer

**MINIMUM REQUIREMENTS.**

**C**

[10]**Physical Requirements**

[11]Strength ........ [12]Weight ........ [13]Height ........ [14]Eyesight ........

[15]Other qualities ........

[16]Reason ........

**D**

**Education**[17] ........

Post-Graduate Work: V IV III II I ½ — College: G IV III II I ½ — High School: G IV III II I ½ — Common School: 8 8 7 6 5 4 3 — None

[18]Degree ........ [19]Subjects required ........

[20]Reason ........

........

[21]Equivalents ........

**E**

**Special Training**[22] ........

V IV III II 18 1 6 3 1 None

[23]Subjects required ........

[24]Reason ........

[25]Equivalents ........

**F**

**Experience**[26] ........

V IV III II 18 1 6 3 1 None

[27]Nature ........

[28]Reason ........

[29]Equivalents ........

**G**

**Technical Skill**[30] ........

Expert — Journeyman — Apprentice — None

[31]Trade ........

[32]Reason ........

[33]Equivalents ........

**H**

**Personal Qualities:** [34]S M E........[35]M F E. ......[36]Age........ to........ [37]Race ........ [38]Citizenship ........

**Judgment**[39] ........

Unfailing: Errors cause personal danger — Good: Errors cause money loss — Average: Errors cause confusion — None

[40]Kind and reason........

**Creative Ability**[41] ........

Highest: Inventiveness — High: Originality — Average: Initiative — None

[42]Kind and reason........

**Supervisory Ability**[43] ........

1000 — 500 — 100 — 25 — 10 — 2 — None

[44]Characteristics of force........

[45] ........

[46] ........

[47] ........

*Courtesy—The Scott Co.*

FIG. 104

PART OF A JOB ANALYSIS WORK SHEET

when the analysis has been written up in its final form, the degrees in which they may be held should be established for the various personnel elements or qualities. The method is illustrated by the following code for evaluating the degree of judgment which is required for a given job.[1] Of course, such codes must be developed to meet the conditions existing in the particular plant.

*Judgment*

| | | | | |
|---|---|---|---|---|
| A—Errors | may | cause | loss of life. |
| B— | " | " | " | personal injury. |
| C— | " | " | " | money loss. |
| D— | " | " | " | confusion—inter-departmental. |
| E— | " | " | " | inconveniences—intra-departmental. |
| F—None required. | | | | |

These code letters may appear in a bracket on the final job specifications, opposite the name of the quality, to enable the interviewer to get a quick, approximate impression of the job.

**Job Classification.** Before the work of job analysis has proceeded far, probably it will be noted that there are jobs in different departments which may differ from one another in so far as the details of performance are concerned. Nevertheless, their personnel requirements are practically identical. In other cases, jobs in different departments may differ only in the names which have been applied to them. It is desirable that all jobs which have the same personnel requirements shall be covered by the same job specification.

To accomplish this, jobs should be classified following their analysis. For the reasons indicated above, this classification may not be the same as that which has been worked out to meet the needs of the production organization. At the start of the work, however, it may be convenient to use the existing classification. As the work proceeds, it may be necessary to change the names of certain jobs because they are misleading. In other cases, the present job name may be eliminated entirely and the work listed under some other job symbol and name. The classification should be based on an analysis of the personnel elements involved in the various jobs. When the work of classification has been completed, job numbers or symbols should be assigned to each job which is distinctly different in respect to its personnel elements.

Job classification facilitates the work of the personnel department by reducing the opportunities for confusion and by simplifying the handling of labor requisitions, requests for promotion, quits, and transfers. All requisitions for labor should bear the number or symbol of the job affected. Each job specification also should bear the num-

[1] *Personnel Management*, by Scott and Clothier, p. 155.

ber or symbol of the job which it covers and in addition the symbols of the jobs from and to which promotion is possible. In addition, job classification will also assist in the development of a rational wage classification.

**The Job Specification.** When the job analysis has been completed, the information is written up in its final form, known as the job specification. The conditions surrounding the job and the duties and qualifications of the employee should be stated in general terms to give the greatest possible elasticity to the description. Obviously, there can be little or no elasticity in so far as the minimum qualifications are concerned. The applicant must have these or he is not eligible for employment. In so far as the desirable qualifications are concerned, considerable elasticity may be possible. Some job specification sheets are so designed that check blocks may be used to indicate the minimum degrees in which various qualities should be present in the applicant and the conditions which surround the job. The nature of the information contained in the job specification is shown in Fig. 105. When the job specification is approved, it should be submitted to the department heads affected for their criticism.

The job specification has a number of advantages. It establishes a mutual understanding between the shop and the office regarding the requirements of the job. Such an understanding greatly improves the efficiency of selection, which in turn is reflected in greater production and less turnover. The job specification also can be used to give the applicant a better understanding of the job and the conditions surrounding it. Too often the interviewer satisfies himself regarding the qualifications of the applicant before sending him to the foreman, but the applicant goes on the job with an incomplete and sometimes erroneous picture of his future employment. The disadvantages of this have been discussed previously.[1] Furthermore, the interviewer cannot be familiar with the training requirements of each job in the plant. With the job specification, these requirements are constantly before him. In some cases the applicant may have the minimum training requirements but additional training may be desirable. If this is the case, the interviewer can notify the training department to this effect. In this manner, the specification links up the work of employment with the work of training. It also has the advantage that it assists considerably in training new interviewers. If they are not particularly familiar with the plant or with the work of employment, the job specification gives them a fund of information which makes it possible for the employment department to maintain a higher quality of service in the selection of employees than would otherwise be the case. Finally,

[1] See page 320.

**WAR DEPARTMENT**
**Air Service, Engineering Division**
**McCook Field, Dayton, Ohio.** Symbol 011

Prepared by Baruch
Date Nov. 86 1922

OCCUPATION Assistant Aeronautical Engineer (Structural

Occurring in:

| MINIMUM REQUIREMENTS | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ed | Exp | Jdg | Ac | S.A | Phys | Wk.C | |
| A | D | D | D | F | F | F | |

| Sections | Branches | Units |
|---|---|---|
| Airplane | Static Test Structural | |

**Duties**

The Airplane Section is concerned in part with stress analysis, structural design, static and aerodynamic test and research work on airplane structure.

In connection with these functions and under general supervision, the Assistant Aeronautical Engineer (Structural) performs technical work of higher than routine grade in aeronautical engineering as it relates to analysis and design of the component members of airplane structure including wings, fuselage, empennage, landing gear, etc. From this information and data as to the general type of airplane structure required, he performs stress and aerodynamic computations for the development of the individual members of the major assemblies of airplanes such as, - deciding upon the shape and size of struts, spars and ribs. He also may carry on research work in special problems, such as: - the effect of combined bending and compression, studies of eccentric moments, etc.

As Assistant to a superior engineer engaged in static or impact tests, he may design special jigs and testing apparatus, make observations, perform the necessary calculations, and write reports and recommendations as to correction of design

**Hours**

8:00 A.M. to 12:00 M. }
12:00 M. to 12:45 P.M. Lunch } Monday to Friday.
12:45 to 4:45 P.M.
8:00 A.M. to 12:00 M. Saturday.

**Minimum Qualifications.**

The Assistant Aeronautical Engineer (Structural) must have graduated in engineering from a college or university of recognized standing, including a course in structural design in the curriculum, and have had at least two years' subsequent technical experience (or post-graduate work) in structural engineering, of which at least one year must have been in stress and aerodynamical analysis or testing of the general structure of airplanes, including wings, fuselage, empennage, landing gear, etc.

In lieu of college graduation in engineering, there may be substituted graduation from high school and four years' subsequent (or graduation from a college or university of recognized standing in a course other than engineering, and two years' subsequent or concurrent) technical training and experience in engineering, advancing in accomplishment com-

APPROVED BY ______________ CH. OF SECT. ________ AIR SERV. ________ CIV. SERV.

*Courtesy—The Scott Co.*

FIG. 105
A JOB SPECIFICATION

the specifications assist in the work of promotion and transfer for the reason that all lines of promotion appear on the sheet, insuring that all who are eligible will receive consideration. In short, job specifications assist greatly in placing the work of employment on a scientific basis.

**The Rating Scale.** The rating scale is intended to furnish a method of obtaining comparable measures of those qualities which are necessary to success in a given line of work, but which are too intangible to be measured objectively, such as ambition, initiative, and personality. In many kinds of work such qualities may have an important bearing on the employee's value to the company and his possibilities for promotion.

In some plants, department heads are asked to rate their employees according to their opinion of their general ability. They may be furnished with some crude form of rating scale in which the qualities to be rated are listed at the left of the rating sheet. At the right may be check columns headed excellent, good, fair, poor. The executive is expected to check the proper column opposite each quality. The objection to such a device is that the executive's opinion regarding the extent to which these qualities are held is likely to be too inaccurate. Furthermore, recent events may unduly color his judgment. If the employee has done something displeasing to his superior, he may be rated unfairly. Previous good work is likely to receive less than its proper weight. It is also true that executives will not agree exactly with regard to the definitions of the various degrees of a given quality represented by the adjectives excellent, good, poor, fair, etc.

The selection of the qualities to be rated also is important. Those characteristics which can be evaluated objectively should not be rated by means of a rating scale. To illustrate, if we have reliable records of individual production, productivity should not be rated by such means.

In view of the above considerations, some rational technique for rating employees may be desirable, at least in so far as certain groups are concerned.

Fig. 106 is an example of a graphic rating scale. The qualities to be rated are listed at the left of the rating sheet. Usually a quality is not indicated by name, but by definition. If the name of the quality does not appear, the rater is forced to read the definition, and as a result it is more likely that he will rate the quality on the basis of the standard definition, rather than on the basis of his own definition, which may be somewhat different. After the definition of each quality appears a line. At different points under the line are descriptive words or phrases indicating the different degrees in which the quality may

## A GRAPHIC RATING SCALE FOR DEPARTMENT HEADS, FOREMEN AND SUPERVISORS[1]

| Item | | | | | | Score |
|---|---|---|---|---|---|---|
| 1. Consider his success in winning confidence and respect through his appearance and manner | Inspiring | Favorable | Indifferent | Unfavorable | Repellent | 4 |
| 2. Consider his success in doing things in new and better ways and in adapting improved methods to his own work. | Highly Constructive | Resourceful | Fairly Progressive | Routine Worker | | 7 |
| 3. Consider his success in winning the cooperation of his subordinates, in welding them into a loyal and effective working unit. | Capable, Forceful Leader | Handles Workers Well. | Fails to Command Confidence | Frequent Friction In His Department | | 6 |
| 4. Consider his success in organizing the work of his department or unit, both by delegating authority wisely and by making certain that results are achieved. | Effective Even Under Difficult Circumstances | Effective Under Normal Circumstances. | Lacks Planning Ability | Inefficient | | 8 |
| 5. Consider his success in making his department or unit a smooth running part of the whole organization; his knowledge and appreciation of the problems of other departments. | Exceptionally Cooperative | Cooperative | Not Helpful | Difficult To Handle | Obstructionist | 10 |
| 6. Consider his success in improving his subordinates by imparting information, creating interest, developing talent and arousing ambition. | Develops Workers Of High Calibre | Develops Workers Satisfactorily | Neglects To Develope Workers. | Discourages and Misinforms Workers | | 8 |
| 7. Consider his success in applying specialized knowledge in his particular field, whether by his own knowledge of ways and means or through his use of sources of information. | Expert | Competent | Uninformed | Neglects And Misinterprets The Facts | | 9 |

Date________________ Final Rating B _______ Total Rating 52 _______

1 - Adapted by permission from a similar scale in "Personnel Management", by Scott And Clothier.

FIG. 106

A GRAPHIC RATING SCALE

be held. For reasons previously stated, the words good, poor, bad, etc., are not used. The rater makes a check on the line at the point which in his opinion represents the degree in which the quality is present.

Values do not appear on the sheet for the reason that they may influence the rating. The evaluation of the ratings can be done in the personnel office by a clerk. The lines opposite each quality are of equal length. A strip of the same length, divided into ten equal parts, is laid on the line. If the phrases indicating the highest degrees appear at the left of the lines, the spaces on the strip are numbered from the right. The clerk notes the space in which the check mark falls and enters that value for the quality accordingly. The total of the scores is a measure of the extent to which the qualities rated are present.

**Correcting for Rating Tendencies.** Usually there are differences in the strictness with which different executives will rate the same employees. With one executive, a score of 75 or better may constitute an "A" rating. With another executive, 65 or better may constitute an "A," for the reason that he rates more strictly. Unless correction is made for these rating tendencies, ratings by different executives for the same employees are not exactly comparable.

Correction may be made by arranging a large number of ratings by a given executive in numerical sequence. Consider that the highest 10 per cent represent "A" ratings, the next 20 per cent "B" ratings, the next 40 per cent "C" ratings, the next 20 per cent "D" ratings, and the lowest 10 per cent "E" ratings. From this analysis the tendency for the executive may be determined. To illustrate, an analysis of a given executive's ratings may give the following results:

| *Rating* | *Numerical scores* |
|---|---|
| A | 60— |
| B | 50–59 |
| C | 38–49 |
| D | 28–37 |
| E | —27 |

Another difficulty is the tendency of raters to be affected by recent events. To get away from this effect, the employee should be rated by more than one executive, who are acquainted with his work.

The executive should take sufficient time in making the rating in order that it may represent his best judgment. Usually he is pressed with work and it is difficult to get him to give this time. Before executives are asked to make ratings, they should be educated regarding the nature and possibilities of the rating scale until they are sold on its use. In addition, they ought to receive some instruction regarding the

making of the ratings. Otherwise the results may lose some of their comparability.

**The Value of Proper Ratings.** Inasmuch as productivity is only part of the story in so far as promotion is concerned, ratings of various intangible qualities which directly affect success may be decidedly valuable. This is particularly true in connection with those occupations which are of an executive nature or which lead to executive work. In connection with clerical work where it is difficult to determine individual productivity directly, ratings may be of assistance in connection with wage adjustments as well as in promotion. Just how far down in the organization the rating scale can be applied profitably is a question which is open to debate. Inasmuch as these intangible qualities have little bearing on the success of the average shop operative, it is doubtful if rating scales should be applied below the rank of foreman or assistant foreman.

**The Selection of Applicants.** In connection with the routine of hiring, the problem of properly selecting applicants has been mentioned. Poor methods of selection may cause great suffering and unhappiness among workers and considerable loss to employers. If the method of selection consists chiefly of attempting to drive the square pegs into the round holes rather than to fit them to the square holes, there will be considerable unnecessary labor turnover in the plant. Unless the employee is adapted to the work which he is performing, he cannot be happy in it and his interest will be most perfunctory. Under such conditions, it is unreasonable to suppose that the quality or the quantity of his work will be highly satisfactory to the management. Eventually he will quit in order to obtain work which is more to his liking, suffering temporarily the hardships of unemployment. For these reasons, much thought has been given to the problem of developing methods which will permit a more scientific selection of employees.

Many methods of selection based on palmistry, phrenology, graphology, physiognomy, or psychology have been used in industry. With the exception of physiognomic and psychological methods, they have not had any considerable application. Physiognomic methods are based on the theory that the mental characteristics and capacities of an individual can be determined by a visual audit of his physical characteristics. It is a common belief that a man can be "sized up" by his appearance. Scientific experiments have shown that the degree of accuracy with which this can be done is very low. Executives who pride themselves on being "good judges of men" often are merely affected by what might be termed a "physiognomic complex." Psychological methods have a scientific basis and seem to offer the only real

hope for the development of scientific methods for the selection of applicants.

**Psychological Tests for the Selection of Applicants.** The prediction of probable performance by means of psychological tests is not particularly new when measured in relation to the development of modern management, but the development of such tests to meet the needs of industry is comparatively recent. Columbia University began to give psychological tests to its freshmen in 1894. However, no considerable applications of psychological methods were made in industry until after the World War.

Psychological tests are devices which are intended to give some measure of mental capacity or ability. The field of vocational psychology is concerned largely with the relation of such tests to vocational aptitudes. The tests are usually an application of the principle of sampling. That is, all of the psychological elements which may affect a man's performance on the job cannot be measured completely, so an attempt is made to get some objective measure of those which appear to be the more important. Similarly, the tests cannot be applied to all of those who are engaged in a given occupation in order to determine the value of the different tests, so they are applied to a representative group. While there is some question regarding the propriety of attaching concrete values to the results of psychological tests, it is desirable from the standpoint of administration and comparability to make the results of the tests as quantitative as possible.

**The Administration of Tests.** In giving psychological tests, there are certain considerations which should be borne in mind. In the first place, the tests should be given under standard conditions. If a test is given to a group of people in a warm, well-lighted room on one day, and to the same group in a cold, poorly-lighted room on the next, there may be noticeable difference in the results.

Furthermore, the subject's attitude is important. If a person takes a test in a highly nervous condition, it is obvious that the results of the test will not afford a true measure of his capacity. It is desirable that the examiner have sufficient personality so that the subject may be restored to as nearly a normal condition as possible. The examiner should be properly prepared so that the tests will run off smoothly. Any hitch in the proceedings may affect the results of the tests seriously.

In this connection, the preliminary instructions are important. Good results cannot be obtained unless the subject is thoroughly familiar with the nature of the tests and the manner of performing them. Where written tests are being given to a large group of subjects, it is

the usual practice to give a verbal explanation of the procedure, an illustration of the manner of performing the tests, and some limited practice with a sample set of tests.

Another factor in the administration of tests is the incentive to perform them creditably. An applicant for a job has a natural incentive to do the best that he can. He wants the job and will go through almost any reasonable procedure to get it. However, the situation is different when psychological tests are given to employees. Probably the best method of determining the value of a test is to apply

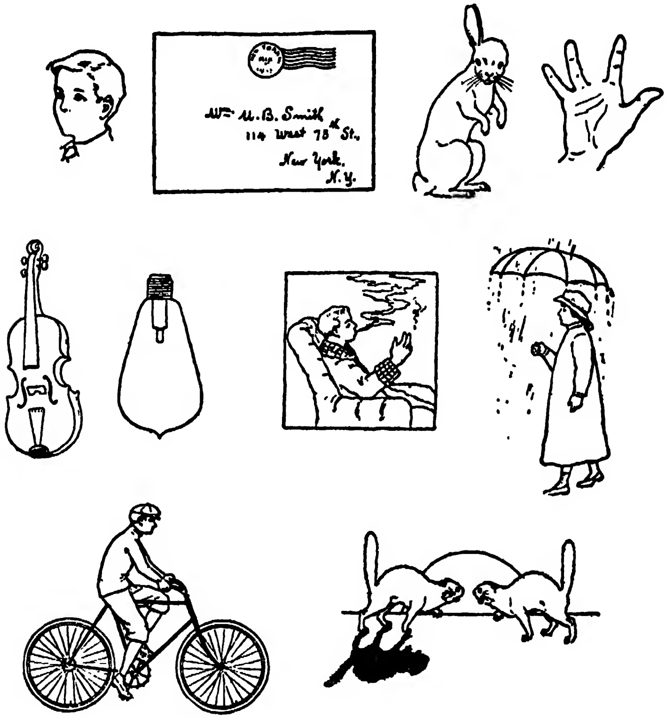


FIG. 107
PART OF A PSYCHOLOGICAL TEST FOR PERSONS HAVING LITTLE EDUCATION

it to the group on which it is to be used normally, and then to check the tests against the actual results on the job. Unfortunately, the group on which the tests are to be used is the applicants. The gathering of actual results after employment involves too much detail and time. Therefore, it is necessary to use the next best group, which is the employees on the job. They are less desirable as subjects, for the reason that they already have their jobs and therefore it will be necessary to supply some other incentives to creditable performance. Such

incentives may be the possibility of promotion, pride of accomplishment, and competition.

**Methods and Types of Responses to Tests.** There are different methods and types of response to tests. The examiner may put certain questions to the subject and he may respond orally. In other cases the questions may be printed on a standard form and the responses may be written in blanks on the form. A third method of response is by performance. The subject may be required to perform certain operations. His performance is checked by the examiner. An example of a test of this kind is the picture test, in which certain important details have been left out of each picture. The quickness with which the subject checks the missing details is a measure, among other things, of his quickness of perception and his ability to correlate.

There are two types of response, free and restrained. In the first type, certain questions are put to the subject and he is permitted to answer them in his own way. The manner in which the answer is given and the quality are the basis of the examiner's judgment of the extent to which the capacity being tested is present. In the second type, the manner in which the response shall be given is indicated in the directions for performing the test. Where tests are being given to a large group, comparability is important and supervision difficult, this type of response is usually the better. It is generally employed in connection with written tests. In addition, certain limits may be set on response. There are two kinds of limits—the time limit and the work limit. With the time limit, a definite time is set within which the test must be completed. The time is so set that even the most intelligent cannot complete it. Unless this is done, it is not possible to test the limit of the particular capacity under investigation. Obviously, the time limit must be set by actual trial with subjects of known capacity. With the work limit, an attempt is made to determine what is the most difficult material that the subject can handle. There is no time limit. The length of time required to complete the test and the quality of the response are a measure of the extent to which the particular capacity is held. In this case, also, the test must be tried out on subjects of known capacity before they can be evaluated.

**Characteristics of the Tests.** The popular idea of psychological tests is that they are devices to test the level of intelligence of the subject. Some of them are designed for this purpose. In many cases, they are merely designed to determine the extent to which certain psychological elements or capacities are present in the subject. In some cases, a high level of intelligence may even be undesirable. But some particular capacity, such as quickness of physical reaction to a stimulus, may be extremely important. Intelligence may be defined as the ability to profit

by previous experiences. The level of intelligence is the sum total of the large number of particular mental capacities which are present to some degree in all of us. Examples of these capacities are ability to associate ideas, memory, reason, ingenuity, motor control, the various senses, and many others. The amount of knowledge which a person possesses is not necessarily an accurate measure of his intelligence, although the degree of his intelligence limits the amount of knowledge which he can acquire and the effectiveness with which he can use it.

Tests used in the selection of employees can be divided into two classes—those which test capacity, or in other words innate ability, and those which test proficiency. Trade tests which are used to test the extent of skill and knowledge are an example of the latter. Tests of capacity can be subdivided into those which test general capacity, or, as it is usually stated, general intelligence, and those which test specific capacities.

**The Selection of the Elements to Be Tested.** The selection of the actual tests to be used depends on the nature of the job and which of the above classes of tests will give the best results. The psychologist usually analyzes the job from the standpoint of its psychological elements before attempting to design tests which will select the proper employees to fill it. He may decide that space perception, ability to distinguish between small-time elements or some other special capacity, or a combination of a number of special capacities, should be present in the applicant if he is to handle the job with the greatest possible success. On the other hand, he may decide that a certain level of general intelligence is necessary.

**The Selection of the Tests.** When the important capacities have been determined, there is still another problem in the event that it is decided to use special ability tests. Shall the important conditions on the job, which affect the ability of the worker to perform his work properly, be reproduced approximately, or, as the psychologist would state it, the total situation, or shall each special capacity be tested separately? In the first case the applicant would be required to perform certain operations which would be similar psychologically to those which he would actually perform on the job. If the job were one requiring the visual inspection of small parts, the applicant might be required to sort out a number of similar small objects in a pan, working against a time limit. Inasmuch as the psychological elements involved in the sorting test and the actual job are about the same, the number sorted with the time limit and the number of errors made would give an objective measure of the extent to which the necessary capacities are present.

On the other hand, it may be desirable to test the requisite capaci-

ties separately. The results of these tests are combined later into a final score. To illustrate this type of procedure, it may be assumed that a particular job requires highly developed capacities of motor control and reaction time. Fig. 108 illustrates a simple test for motor control. The subject moves a pencil between the lines of the pattern, completing each step in time to the beat of a metronome. The number of times his pencil touches the lines gives a measure of the steadiness with which he controls the muscles used in moving his pencil. In order to get his reaction time, a light and key, electrically connected with a chronoscope, may be used. When the light is flashed by the observer, the subject presses the key. The difference between the time when the light is flashed and when the subject presses the key is recorded by the chronoscope. This difference is a measure of the time required for the subject to react to the stimulus.

FIG. 108
A Test Motor Control

**The Arrangement and Application of the Tests.** The arrangement and application of the tests is also important. In this connection, tests may be classified as either speed tests or power tests. In the speed tests, the subject works against a time limit. The operations to be performed are all of equal difficulty. In the power test, the operations increase in difficulty. In this case an attempt is made to determine what is the most difficult operation that the subject can perform. The length of time required and the quality of the result are a measure of this. The type of test giving the best results is a problem which the psychological analyst must solve.

**Correlation with Actual Results.** For practical results, the tests must be so designed that they will give quantitative measures of the capacities which are being tested. They must be unequivocal and as simple as possible in order that they may be applied by the personnel office in the normal routine of employment. The values to be attached to the various tests must be determined by actual trial with employees of known ability, who are regularly engaged on the job for which the

test is designed. The results of these tests are correlated with such criteria as ratings by superiors, production figures, volume of personal sales, or similar data. The criterion, of course, should be the thing which it is desired to predict. For instance, if those who rank high in the tests also rank high in production, then the test probably can be used successfully to predict the productivity of applicants on the job in question. Three scores usually are determined, the maximum score, the average score, and the critical score. Particularly in connection with tests for general intelligence, it may be desirable to know the maximum intelligence which can be employed on the job. In some jobs of a routine nature, those with too great intelligence cannot be retained for any great length of time. The maximum score indicates that those who make a greater score than this should not be employed for the job in question, for the above reasons. The average score is the average of the test scores. The critical score indicates that those who make less than this score in the tests should not be employed, for the reason that probably they will prove to be unsatisfactory for this type of work. This is the standard which is important and which should be upheld in the selection of applicants.

**Importance of Competent Counsel in the Development of Tests.** Considerable space has been devoted to the consideration of the development and use of psychological tests in the selection of applicants, not because they are widely used at present, but because they are generally misunderstood, and as a result their great possibilities are not realized. It is out of the question for the majority of concerns to employ a full-time psychologist. However, a great many of these concerns have certain jobs on which there is excessive turnover and for which psychological tests could be used profitably in the selection of applicants. In such cases, a consulting psychologist might be employed to advantage. These tests usually cannot be developed by the average personnel executive because he lacks the proper psychological background and training.

**Trade Tests.** Trade tests are intended to indicate the present ability of the applicant with regard to a given craft or job. They do not necessarily indicate his ability to acquire greater skill or knowledge of the vocation or his possible development for promotion.

Inasmuch as the tests endeavor to determine a certain knowledge content, the items in the test all bear on the general subject of the occupation.

Trade tests may be classified under four heads according to the manner in which they are given:

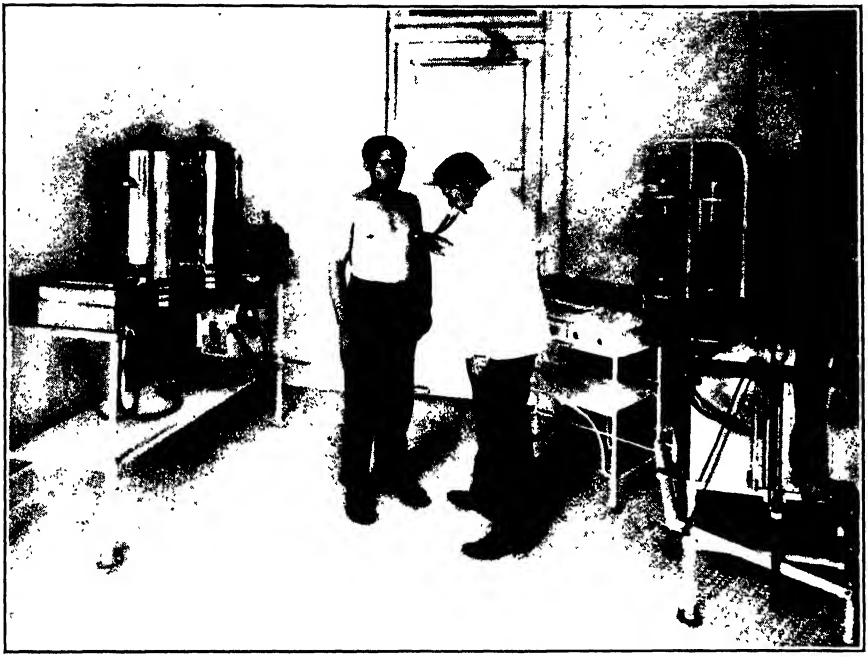
1. *Oral Tests* in which certain questions relating to the occupation are put to the applicant. His answers are given orally.

2. *Picture Tests* in which certain conditions of work are illustrated by pictures. The applicant is expected to analyze and explain them.

3. *Written Tests* in which questions relating to the occupation are put to the applicant in writing. The answers are returned in the same manner.

4. *Performance Tests.* The applicant is asked to perform certain fundamental operations of the craft. The facility with which he performs them indicates the degree of his skill.

As in the case of psychological tests, the trade tests should be checked against the performance of employees of known ability. On the basis of such checks, the applicants are graded according to their test scores as novice, apprentice, journeyman, or expert.



*Courtesy—National Cash Register Co.*

PLATE 24
EXAMINING AN APPLICANT

*Courtesy— National Cash Register Co.*

PLATE 25

A COMPANY DENTAL CLINIC

# CHAPTER XXIV

## PERSONNEL CONTROL—PROMOTION AND WAGES

**Promotion and the Worker's Interests.** The interest of the worker in his job is a powerful factor affecting both his productivity and his length of service with the company. The knowledge that promotion in pay, position, or privilege is based on ability, is a great stimulus to an active interest in the job and the company.

S1101 20M-11-26-229 1 *Employes Attendance Record* *Clock No.* ______

*Name* ______ *Date Employed* ______ *Dept.* ______

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | Late | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Absent | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Feb. | Late | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Absent | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Mar. | Late | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Absent | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Apr. | Late | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Absent | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| May | Late | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Absent | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| June | Late | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Absent | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| July | Late | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Absent | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aug. | Late | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Absent | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sept. | Late | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Absent | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Oct. | Late | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Absent | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nov. | Late | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Absent | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dec. | Late | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Absent | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

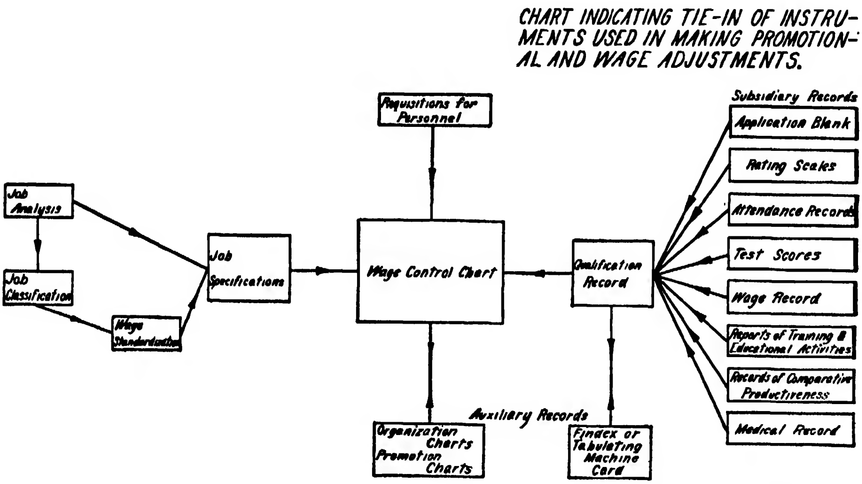
*Courtesy—Firestone Tire and Rubber Co.*

FIG. 109

AN ATTENDANCE RECORD

In a large concern, the distance in terms of organization, between the managing executives and the employees at the bench is great. Considerable unfairness to employees, which would not be condoned by these officials, can occur before they are aware of it. Too often the complaint is heard that it is necessary to be a friend or relative of the foreman or department head if one is to get promotion. Such conditions are hardly conducive to loyalty or interest in one's job. For these reasons, many concerns have worked out definite promotion policies and logical lines of promotion.

**The Promotion Policy.** The basis of the promotion program is the adoption of the policy of promotion from within, the introduction of comparable measures of ability such as tardiness and absence records, production or efficiency records, rating scales, intelligence ratings, length of service records, and similar bases, and the development of logical lines of promotion. •An air of mystery surrounding the processes of promotion is not desirable. The basis and reason for promotion should be understood by all employees. In considering the development of promotion policies, it should be borne in mind that promotion may be of three kinds—promotion in pay, in position, or in




Courtesy—H. B. Bergen.

FIG. 110

THE RELATIONS OF INSTRUMENTS IN PROMOTIONAL AND WAGE CONTROL.

privilege. An instance of the latter is the privilege of choice of runs often granted, in the order of their seniority, to street railway motormen and conductors.

**Promotion from within the Organization.** The policy of promotion from within presupposes that when a vacancy occurs it will be filled from some lower, eligible position in the hierarchy of jobs; that in so far as such a thing is possible, there will be a step up all along the line of promotion. Nothing is more discouraging to the able employee, who has worked conscientiously, than to have an outsider brought in to the organization to fill a position for which the employee is eligible and qualified. The effect on the employee's efficiency and morale is decidedly adverse. It is possible, however, that the policy of promotion from within can be applied to the point of diminishing returns. Unless the employees keep abreast of developments in their respective fields,

the organization may suffer from dry rot. In such cases the injection of new blood and new ideas into the organization may have a stimulating and beneficial effect.

Quite often one hears an industrial executive say that in his organization, jobs are filled by promotion from within on the basis of ability and fitness for the job. While usually there is no question as to the sincerity of the statement, there may be some question as to its accuracy. In many cases, investigation will show that the executive has only a hazy, general knowledge of the relation of various jobs to one another in so far as their promotion possibilities are concerned. While he may consider that he has sufficient knowledge of the personnel requirements of these jobs, it is not unusual that in this respect also his knowledge is anything but accurate. If in addition he has no complete records from which the ability and fitness of the different candidates for promotion can be determined adequately, it is inevitable that maladjustment and injustices will result.

**Working Out the Lines of Promotion.** The information necessary to the working out of promotion relations can be obtained from the job analyses. After the analyst has made a comparison of the personnel elements in the various jobs, he lists tentatively for each job the different jobs which apparently have a promotion relation to it. For instance, in the case of the job of machine shop foreman which is assumed to be job No. 110, there might be some such relation as that indicated below:

| *Promote to* | *Job* | *Promote from* |
|---|---|---|
| *Job No. 112* | | |
| Asst. supt. of | Foreman of | Job No. 25 |
| machine shop | machine shop | Job No. 37 |
| *Job No. 150* | | |
| General foreman | | Job No. 51 |
| of machine shop | | Job No. 75 |
| *Job No. 300* | | Job No. 86 |
| Inspection supervisor of | | Job No. 101 |
| machine shop | | Job No. 109 |

It may be that promotion from job No. 25 leads to other jobs besides No. 110. They are not shown in the above analysis for the reason that it applies particularly to job No. 110. They would all be shown on a similar analysis for job No. 25. Some jobs may prove to be blind-alley jobs. They should be so indicated and the fact taken into consideration in the determination of starting pay.

In some cases, the lines of promotion are shown graphically by means of promotion charts such as that shown in Fig. 111. Aside

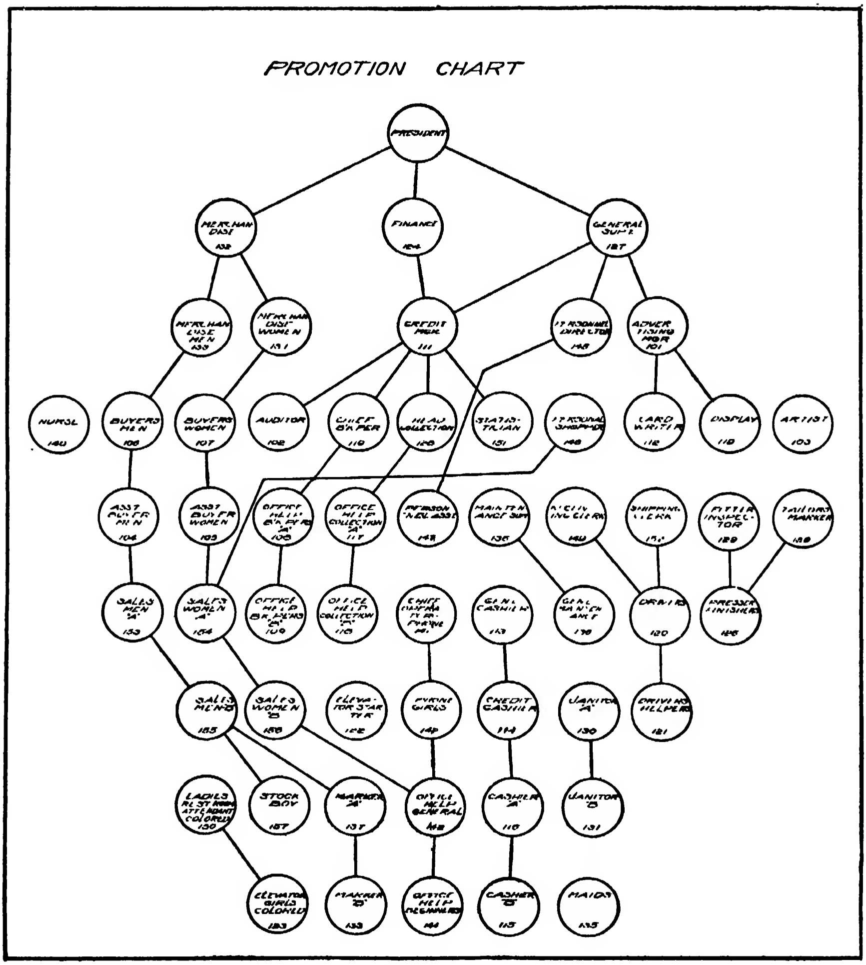



FIG. 111
A Promotion Chart

from the expense of making such charts, there is the objection that they are too rigid. Changes in the organization or the products may affect the promotion possibilities of different jobs. Jobs never are entirely static. For this reason, the promotion chart may become obsolete in a relatively short length of time. It has the advantage, however, that it gives a complete picture of the promotion situation in the plant as a whole.

As stated previously, the promotion information regarding a job should be entered on its specification.

**Promotion in Pay.** In addition to promotion in position, there should be the possibility of promotion in pay. Not only should the starting wage on a job be set with regard to the going rates of wages and the various personnel elements in the job, but also with regard to wage promotion possibilities in order that financial recognition of efficiency, length of service, or other desirable qualifications can be made. This problem is intimately connected with the problem of wage classification.

**The Determination of Wages.** The fairness of the employee's wages affects his interest in his job quite as much as, if not more than, the opportunities for promotion in position. If the wage is insufficient, financial worries will cause dissatisfaction, which in turn may be reflected in low morale, high labor turnover, and decreased production. If the wages are not set fairly as between employees or similar classes of work, again dissatisfaction may result. The effect of fair wages on morale, turnover, cooperation, and productivity is so direct that many concerns have established the definite policy of paying somewhat higher than the going rates. They consider that this practice is justified by the fact that they get more production of a better quality due to the fact they are able to attract and hold a better class of workmen, and can develop better cooperation and morale.

Whether the employee is working on a day rate or under some system of wage payment in proportion to production, his total wages can be divided, theoretically, into two portions, that which corresponds more or less closely to the going rate of wages and that which is in the nature of a reward for more than ordinary service. In connection with wage classification, the analyst is concerned chiefly with the first portion which is usually termed the base wage.

The going rate of wages for a given class of labor at any given time is the normal rate of compensation at that time for average production under the prevailing conditions of management, supervision, and shop practice, in the particular labor market. In the opinion of most economists, it is determined largely by the principle of the marginal efficiency of labor. In other words, the productivity of the last worker who can be employed profitably determines the rate of com-

pensation for the particular class of labor. While this principle may determine base wages over a long period of time, at any given time they may be affected by many other economic forces. It presupposes that labor will quickly flow to those points where there is the greatest demand, best conditions, and the highest wages—a mobility which does not actually exist. Actually, base wages may be affected by such factors as union control of the labor supply resulting in restriction of output, restriction of apprentices, and superior bargaining power resulting from organization, the relations of the supply of and demand for labor, the state of enlightenment of management, the general outlook for business, and many others.

As between different occupations, the base wages tend to be determined by the various wage differentials which affect these occupations, such as skill, hazard, hours of work, seasonal fluctuations, permanence of employment, location of the work, and others. The die-sinker gets a high rate because his work requires certain rare capacities and great skill, gained only after a long apprenticeship and considerable experience. However, wage differentials are a force which affect wages slowly over a considerable period of time. As in the previous case, other factors may enter the situation which at the moment are more powerful.

**Wage Classification.** Wage classification has to do with the determination of the relations of these differentials in various jobs and the setting of base rates which will be fair with regard to them. It is not unusual to find that the same job has widely differing base rates in different departments of the same plant. Furthermore, it may be discovered that the rates paid for a particular job vary unjustifiably within the same department. One employee in a given department may receive a rate that is considerably above the average on the job, for the reason that he is not only a good workman, but a good bargainer with the foreman. Similarly, another employee who may be equally good may receive considerably less, largely for the reason that he has not the same strong personality. Reasonable variations in wage rates on the same job are to be expected, due to differences in ability, length of service, or for other reasons. However, unless such variations are controlled, they may be a cause of great dissatisfaction and loss to the company. In connection with wage classification, the different jobs in the plant should be analyzed to determine the relations of their differentials. Having determined these relations, hiring rates, which in most plants are the base rates, should be established for each job. Finally, the normal range of wages which can be paid on each job should be determined. This range should be sufficient to permit reasonable wage promotion. Requests for increases in rates should have

the approval of the employment manager in order to prevent individual rates from getting out of the normal range unless there is proper justification.

It is recognized that base rates in the plant must be adjusted from time to time to accord with changing business and labor conditions. However, such changes should be made with regard for the differential relations of jobs, as far as possible. While it is not absolutely necessary, it is evident that a wage classification can best be made after a job analysis and job classification have been worked out.

**Wage Payment in Proportion to Production.** As previously stated, under any system of wage payment, a portion of the pay of the better employees may be considered to be a reward for more than ordinary productivity. Even in plants which use the day-rate system and which operate under conventional management, it is not unusual to find that the more skilled and more productive workers are paid considerably above the going rate of wages for the particular class of labor. While a part of this increased pay may be accounted for by length of service or other considerations, a part of it is clearly a reward for better than ordinary performance. A great many concerns have what are commonly termed wage-incentive plans.

A wage-incentive plan is one in which the additional remuneration offered for more than ordinary accomplishment is directly related to the extent of that accomplishment. This definition excludes such indirect incentives as Christmas bonuses, profit shares, and rewards of a similar nature. Sometimes wage-incentive plans are intended to develop or maintain a high standard of quality. More often they are intended to stimulate production.

**Considerations Affecting the Offering of Wage Incentives.** In the development of wage-incentive plans there are certain considerations which are most important. In the first place, such plans should be based on production standards which have been determined by analytical methods, such as time study. In most cases, production standards and piece rates determined by the estimate of the shop foreman or from past production records are not trustworthy. Regardless of how much experience he has had, no foreman can mentally evaluate the various elementary operations which enter into a job, make allowances for fatigue, personal needs, and other factors, and accurately estimate the time required per piece to perform the operation. Furthermore, under ordinary conditions of supervision, the production of the average worker is considerably less than the production of which he is capable, provided proper working conditions and reasonable wage incentives are supplied. Piece rates set from past production records are little better than estimates, for the reason that they include inaccu-

racies and lost time, such as delays due to machine break-downs, which have no relation to the worker's natural ability to produce. For these reasons, such production standards or piece rates are often exceeded by a considerable margin. The unusual earnings of the workers are likely to excite the cupidity of the management, which promptly cuts the piece rate. Often the workers speed up to a higher rate of production in order to maintain the high wages which they have been enjoying. The piece rates may be cut again as individual earnings approach their former levels. After cuts of this kind have been made a few times, the workers realize that if they turn in earnings above a certain amount there is danger that their rates will be cut. Consequently as their earnings approach this figure, their production may be expected to slacken to avoid "killing the job." The practice of rate-cutting tends to limit individual production, although greater production may be obtained than under the straight day-rate system. The management merely pays a somewhat higher wage for somewhat greater production. It is not getting the most out of its men or machines. Consequently, its unit costs are not the attainable minimum.

It is sometimes charged that the practice of rate-cutting speeds up the worker to the point where he may be injured physically and mentally, due to cumulative fatigue. Undoubtedly this may be true where conditions such as described above exist. Such practices, of course, are opposed to the spirit and principles of scientific management. However, it does not take the employees long to discover what are the maximum earnings which can be made in a day without subjecting the job to rate-cutting. When rates are made for new jobs, these earnings in general will not be exceeded.

As a result of experiences with wage-payment systems, production standards in the better managed plants not only are determined by time study, but often are guaranteed against change, except in the event that there is some material change in equipment, methods or product, which change the character of the operation distinctly. With a guaranty of this kind and the confidence of the workers, it can reasonably be expected that they will give the maximum production which can be maintained continuously without injury to themselves. It should be obvious that the guaranties should be made in good faith. However, concerns sometimes make trivial changes in an operation if the operator consistently makes unusually high earnings, and then use this change as a pretext for retime-studying the job. This practice is merely rate-cutting under a different name, and if indulged in sufficiently will have the same results. The time-study department should be responsible for the correctness of the production standards which are given to the shop. If a mistake is made, it is the management's mistake, not the men's. As

a matter of fact, the actual loss to the company from an incorrect production standard usually will not be great. The decreased unit overhead charge resulting from increased production partially if not entirely offsets any wage loss resulting from the error. In addition, the company has strengthened the employee's faith in its fairness, which may be worth more than any saving which might result from readjusting the production standard.

In addition, some concerns guarantee the base-rate earnings of their employees. If for some reason beyond his control the employee fails to make earnings under the incentive system which are equal to his day-rate earnings at his base-rate, he receives his base wages. This is done to protect the employee against loss of earnings due to interruptions to production for which he is in no way responsible. Of course, if the production standard is too high or the amount of the incentive or bonus is too small, there is the danger that the employee will tend to sag back on his guaranteed base rate.

Due to fluctuations in business, there will be times when it will be necessary to make adjustments in wages. During periods of great business prosperity, when prices and the cost of living are mounting rapidly, and there is keen competition for the available supply of labor, it may be necessary to make such adjustments frequently. Obviously, no difficulty is encountered when these adjustments are upward. However, when it is necessary to reduce wages, considerable dissatisfaction may be caused, and in some instances active opposition. It is desirable to avoid the appearance of rate-cutting, if possible, because of the disfavor which may be reflected on the whole incentive system. For this reason it is better to express the production standard in terms of time units rather than in terms of monetary units. Time units have a constant value, while monetary units fluctuate with the purchasing power of the dollar. The distinction between the base rate and the production standard will be more clear in the mind of the employee if his job instructions include some statement such as, "The production standard for this job is 18 pieces per hour. The base rate is $0.45 per hour. The piece rate, therefore, is $0.025 per piece. The production standard is guaranteed against change, except in case of a change in the product or the process which materially changes the operation. The base rate is guaranteed except in case of changes in business conditions which necessitate a general adjustment of wages."

Another reason for stating the production standard in terms of time and one which is equally important is that by so doing emphasis is placed on the time element in production. Inasmuch as the management is primarily interested in the reduction of production time per

piece, any statement of the production standard which tends to direct the attention of the employee to the reduction of this time is desirable. A number of wage-incentive plans have been worked out on this principle.

A practice which has been adopted by some concerns, and which has a rather close relation to the above considerations, is the separation of the employee's incentive wages from his base wages. If the total wages of the employee are lumped together in the same pay envelope, there is some danger that the value of his incentive wages, as a stimulus to increased production, may tend to diminish gradually. The employee may tend to consider his incentive wages as part of his regular pay. Whether it will have this effect depends to a large extent on the nature of the wage-incentive plan. To avoid the possibility of this, some concerns have gone to the extent of paying the employee's wages in two separate envelopes, one of which contains his regular wages, while the other contains his incentive wages. This practice involves extra work in making up and handling pay. To eliminate this extra expense and get the same effect, other concerns have printed a form on the face of the pay envelope on which is entered separately the amount of the base wages and the amount of the incentive wages. For instance, if the employee were working on some bonus plan, the face of his envelope might carry information similar to the following:

Employee's name.......................................
Employee's number....................................
Base wages..............................................
Bonus wages............................................
Total wages.............................................

While the employee's base wages will remain relatively constant, his bonus wages will fluctuate with his production. It is this part of his wages that he is able to affect through his own efforts. The emphasis which this distinction places on the incentive wages, in itself acts as a stimulus to production.

Another consideration in the introduction of an incentive plan is its effect on the quality of the product. The natural effect of a wage incentive is to stimulate the quantity produced per employee. Inasmuch as the employee is interested primarily in producing the maximum quantity per unit of time in order that he may enjoy maximum earnings, there is a natural tendency to slight quality. Therefore the wage-incentive plan should be tied up with the control of quality through adequate inspection. A common practice is to penalize the employee in some manner for work of an inferior quality, provided he is responsible for it. This may be accomplished by requiring that the employee must reprocess poor work on his own time, by specifying that he shall

lose his bonus if the amount of scrap produced is above a given percentage, by recording his scrap percentage on his history card as a factor to be considered in making wage increases, lay-offs, etc., or by other means. The effect of a wage incentive on quality may not be so great as is usually supposed. Where the payment of the incentive is based on standards which have been determined by time and motion study and the employee has received proper training in the best method of performing the operation, the result may be that actually there will be an increase in the quality of the product rather than a decrease.

In selecting a wage-payment plan, the question of simplicity also must be considered. There are some plans for wage payment in proportion to production which are so complicated that it is difficult for the employee to determine what are his bonus earnings. If he cannot understand the basis on which his bonus is determined, there is likely to be dissatisfaction and a feeling that he has been unfairly treated when it happens that his bonus earnings are not so great as he expected them to be. This feeling of dissatisfaction may lead to open opposition to the plan. Furthermore, the incentive value of the plan is greater if the employee is able to check his earnings during the day, and the extent to which he is approaching the standard of production.

Following are brief statements of some of the more important wage-payment methods.

**The Day-Wage Method.** The day-wage method is probably the oldest form of wage payment. In many industries and for many types of work, it is the most common form. Under this system the employee is paid a certain rate per hour for each hour during which he is at work in the shop. There is no direct connection between the rate of production on any given job and the pay which he receives, although, as stated previously, there may be some indirect connection, inasmuch as the better workmen usually have a higher rate of pay. The employee is expected to produce a normal amount of work of the desired quality in return for this hourly rate. What constitutes a normal amount of work depends largely on the ideas and experience of the foreman, local conditions, the class of work which is being produced, shop conditions, and the excellence of the supervision. A part of the foreman's job is to see that the men under him work steadily and accomplish what the management believes to be a fair day's work. Obviously, the system depends on past experience, good supervision, and drive. The straight hourly rate gives an incentive to the man who is not very ambitious to do the least amount of work which will permit him to escape the censure of his foreman.

**The Piecework System.** One of the oldest methods of wage payment in proportion to production is the straight piecework system. Under

this system the employee is paid for his production at a given rate per piece. The hourly production which the employee should attain is determined from past production records, the estimates of the foreman or some other competent person, or by a combination of both methods. Usually the employee is paid only for the amount of work which he produces. If delays in production occur which are the fault of the management, it is the misfortune of the employee. As previously stated, the inaccurate method of setting the rate paid per piece often leads to rate-cutting and attendant evils. While the incentive value of straight piecework is greater than that of daywork, it is not so great as that of some other forms of wage payment in proportion to production, because of the limiting effect of the fear of rate-cutting and the fact that there is no definite goal toward which the employee is working. If he turns out 485 pieces per week rather than the standard of 500 pieces, the effect on his pay envelope at the end of the week is relatively slight. If it happens that he does not feel particularly like working on a given day, this difference in pay, in many cases, is not sufficient to sustain his production.

**Guaranteed Piecework.** Modern installations of piecework differ from the above in that the piece rate usually is based on production standards determined accurately by means of time and motion study. Furthermore, the employee's base-rate earnings usually are guaranteed against loss due to interruptions to production. In most cases, the production standards are guaranteed under the conditions previously discussed.

**The Taylor Differential Piece Rate.** While at the Midvale Steel Company, Dr. Taylor developed a method of wage payment in proportion to production known as the differential piece-rate system. Under this system, the production standards are determined by time and motion study. On the basis of the standard, two rates are determined for each job. The high piece rate is allowed to those who produce at a rate equal to or greater than the standard rate of production. It is so set that the employee is given a considerable incentive to make the standard. The amount of this incentive will vary with the class of work. For ordinary light machine-shop work, the rate would be such that the employee could earn about 30 per cent more than ordinary day wages. If the employee fails to produce at the standard rate, he is paid for his work at the low rate, which is so set that the employee can earn slightly more than ordinary day wages. As a result, the employee is penalized severely for his failure to make the standard rate of production. Because of this, the differential piece-rate method has a high incentive value. With training and sustained effort the average workman can attain the standard regularly without injury to himself. While

the plan has a high incentive value, it usually is difficult to introduce, for the reason that it may take some time to train the average employee to reach the standard of production. During this time he may become discouraged and quit.

**Time Work with Production Standards.** Some concerns prefer not to offer a direct financial incentive for better than normal production. Usually, they are impressed with the fear that a direct financial incentive may result in the deterioration of the quality of the product. In a few cases, they have adopted the method of timework with production standards as a substitute.

Under this method the production standards are set by time and motion study, although in some plants they are merely estimated. The time required to complete a job is recorded. By comparison with the standard for the job, the workman's productive efficiency for that job is determined. At the end of a given period, usually one month, the average efficiency of each workman is determined for the period. In each shop the efficiency record of the men in that shop is posted, the names being arranged in the order of their efficiency ratings.

Often the men are graded according to their efficiency. For instance, those having an average efficiency of 90 per cent or better are considered "A" workmen; those having an average efficiency of 80-89 per cent, "B" men; those having an average efficiency of 70-79 per cent, "C" men, etc. Wage rates also may be graded according to the same classification. The "A" men may get a rate of 70 cents per hour; the "B" men, 65 cents per hour; the "C" men, 60 cents per hour. An "A" man must maintain an average efficiency of 90 per cent or better in order to remain in the "A" class. To illustrate, if he maintains an average efficiency of 90 per cent or better during the present month, he will be paid at the rate of 70 cents per hour during the next month. However, if next month his average efficiency has fallen below 90 per cent, say to 86 per cent, during the following month, his rate automatically drops back to the "B" rate of 65 cents per hour.

In addition, the men may be given to understand that in times of slack business they will be laid off in the inverse order of their efficiency ratings—the "C" men first, the "B" men next, and the "A" men last. Furthermore, the efficiency ratings should be an important factor in the determination of whom shall be promoted in position.

Obviously the incentive value of this plan is not so high as in other plans in which there is a more immediate reward for productive effort. Furthermore, the somewhat less tangible character of the incentive tends to depreciate its effectiveness in stimulating and maintaining production. Its incentive value lies in the hope of getting or holding a day

rate considerably above the going rate of wages for the particular class of work, the fear of discharge, and the hope of advancement.

**The Halsey Premium Plan.** In 1891, Mr. F. A. Halsey presented to the American Society of Mechanical Engineers a plan for wage payment in proportion to production which has become known as the Halsey premium plan. An allowed time is determined for every job. In the original plan this time was determined from past production records or the estimate of some competent person. As a reward for increased production, the workman received a premium which consisted of a certain percentage of any saving of the allowed time which he could make. The usual reward was 50 per cent of any time saved, valued at his hourly rate.

The standard tended to be a drifting standard. The production standards tended to become more exacting as those responsible for setting them became more familiar with what the men could do under the urge of an incentive, and with the approximate amount of inefficiency included in past production records. In modern installations of this plan, the production standard is determined by means of time and motion study. The allowed time is the standard time plus a suitable allowance as an incentive.

The incentive value of the Halsey plan is good inasmuch as there is a definite standard against which the man works. It is not so great as that of the Taylor differential piece rate for the reason that the employee's reward is not dependent on maintaining the standard rate of production, but merely on bettering the allowed time. If he completes the job in only slightly less than the allowed time he gets some reward. For this reason, it is an easier plan to introduce. Furthermore, the idea of a fifty-fifty division of any savings of the allowed time usually appeals to the workman as being fair. Finally, the plan is readily understood by the average workman, and he can easily compute the amount of premium that he has earned, at the completion of the job.

**The Rowan Premium Plan.** A Scotch manufacturer, James Rowan, devised a plan which tends to prevent the workman from "running away with the rate." The plan is a variant of the Halsey plan. The premium allowed is the ratio of the time saved to the time allowed multiplied into the time actually taken, valued at the workman's hourly rate. The plan tends to limit the possible earnings to twice the man's daily wage at his hourly rate. The practical significance of this is that if an error in determining the allowed time has been made in favor of the workman, it is less probable that he will make earnings which are out of all proportion to the savings effected. The plan is somewhat more complex than the Halsey plan and therefore is less easily under-

stood. Furthermore, it may cause some dissatisfaction among the employees unless the allowed time is based on a standard time which has been accurately determined by time study, for the reason that the workman's share of the savings decreases as his rate of production increases.

**The Gantt Task and Bonus Plan.** This plan was devised by H. L. Gantt, an early associate of Taylor's in the development of scientific management. In this plan, a definite premium is allowed for the completion of the job in the standard time.

In its original form, a standard time for a job was determined by time study. If a workman completed the job in the standard time, he received, in addition to his actual time, a bonus which was a definite percentage of the standard time. To illustrate, if the standard time were 10 hours and the percentage were 25 per cent, the workman would be paid for 12½ hours at his hourly rate, provided that he completed the job in 10 hours. There was an incentive to complete the job in less than the standard time, as the less the time that was taken, the greater the number of jobs that could be completed in the course of the day, and therefore the greater the number of bonuses that could be earned. In the plan's present form, the workman is paid the bonus plus the standard time, valued at his hourly rate, if he completes the job within the standard time. In effect, he is paid a high piece rate.

The Gantt task-and-bonus plan has a high incentive value, due to the fact that the employee receives a generous bonus if he completes the task within the standard time and receives only his day wage if he fails to do so. In addition, the plan has the advantages that it is easily understood by the workmen, and it avoids low wages, due to failure to meet the production standard, by guaranteeing the base wages.

It may be difficult to install, for the reason that the production standard usually is high. In order to attain it, the average employee must apply himself diligently and must receive instruction in the best method of performing the operation as determined by time study. For the average employee, this probably means a period of discouragement, until he gets the knack of the new method and is able to meet the production standard regularly.

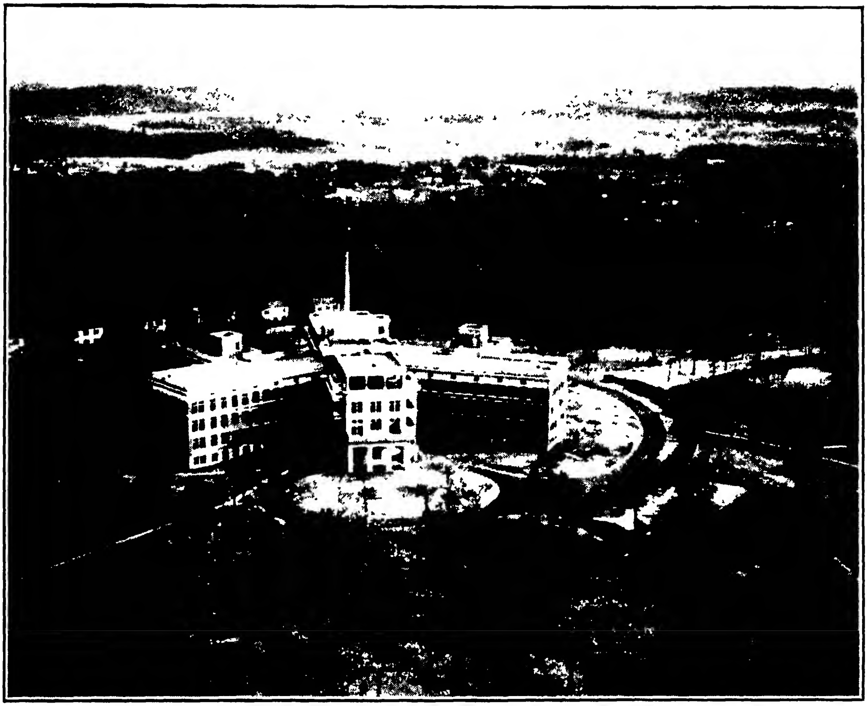
**The Emerson Efficiency Plan.** The plan was designed by Harrington Emerson. It is intended to lead the employee easily toward greater productivity. The standard time for each job is determined by time study. For any job, the workman's efficiency is indicated by the ratio of the standard time for the job to the time actually taken. However, the man's bonus earnings are not computed for each job, but are de-

termined by his average efficiency during the pay period. If the period is one week, then the total of the standard times for the bonus jobs completed during the week, divided by the total time actually taken, will give the efficiency of the workman for the week. Up to 66 per cent efficiency, the man receives straight day wages. At 67 per cent efficiency, he receives a small bonus. This bonus increases as the man's efficiency increases, until at 100 per cent efficiency, he receives a bonus which is usually 20 or 25 per cent of the standard time, valued at his hourly rate. Beyond this point the bonus increases with increased efficiency at the same rate. The manner in which the per cent of bonus increases between 66 per cent and 100 per cent efficiency is a matter of arbitrary determination.

The plan makes it possible for almost every employee to earn some bonus almost as soon as the plan is introduced. For this reason the resistance of the employees to the plan is reduced to a minimum and its ease of installation increased accordingly. While it is easier to install, the incentive value of the plan is less than that of either the Gantt or the Taylor plan. The reward is based on average performance over a period of time. The employee is not sharply penalized for failure to complete a specific job within the standard time. The probable greater ease of installation may make it difficult for the average workman to tell just where he stands with regard to his bonus earnings at any time during the pay period, even when bonus tables are used to avoid the computation of percentages.

Other advantages claimed for the plan are that it can be applied to gangs in which the men work at different rates, and that it can be applied in shops where only part of the work is on bonus, the rest being on a straight day rate.

**The Parkhurst Differential Bonus Plan.** In many respects this plan is merely a variant of the Emerson efficiency plan. The increase in bonus which the workman receives is approximately related to his increase in efficiency. Although it has not been the case in all installations, bonus payments usually begin at about 60 per cent efficiency. At this point, the worker receives a small bonus which amounts to about 7 or 8 per cent of his day wages. The amount of bonus received does not increase in a smooth curve to full bonus at 100 per cent efficiency, but rather in a series of steps which approximates such a curve. For ordinary shop work, the bonus at 100 per cent efficiency is about 33 per cent of the man's time at his day rate. The points in the scale of efficiency at which the bonus increases may not always occur at even intervals. Furthermore, the increases in bonus may not be uniform. To facilitate the computation of his daily earnings, the



Courtesy—U. S. Steel Corp

PLATE 26
AN EMPLOYEES' HOSPITAL

*Courtesy—National Cash Register Co.*

PLATE 27

ONE OF FOUR DINING ROOMS IN A LARGE PLANT

relation of efficiency to bonus and earnings often is expressed in the form of a bonus chart. For a given job for which the standard time is ten hours, the chart shown below might be used.

| *Time actually taken—hours* | *Bonus time allowed—hours* |
|---|---|
| -10 | 3.33 |
| 10.0-10.5 | 2.87 |
| 10.5-11.1 | 2.59 |
| 11.1-11.8 | 2.29 |
| 11.8-12.5 | 1.94 |
| 12.5-13.3 | 1.55 |
| 13.3-14.3 | 1.11 |
| 14.3-15.4 | .60 |
| 15.4- | Day rate |

Above 100 per cent efficiency, the workman receives the same amount of bonus that he receives for 100 per cent efficiency plus the value of the standard time. In other words, what he really gets is a high piece rate.

Like the Emerson plan, the Parkhurst differential bonus plan has the advantage that it is relatively easy to install for the reason that the men begin to earn some bonus at a relatively low point of efficiency. Although it is more complex than some of the other plans, the use of bonus charts makes it fairly easy for the workman to compute his earnings. The incentive value of the plan is better than that of the Emerson plan for the reason that the amount of bonus is related directly to the particular job. However, the bonus steps are a disadvantage in that it requires a considerable increase in efficiency to progress from one step to the next. While this may be relatively easy at first, it becomes quite difficult as the workman approaches 100 per cent efficiency. Therefore, there is danger that less ambitious workmen may rise to a fairly satisfactory level of efficiency and then rest on that particular step.

**The Bedaux Premium Point System.** In this plan each job has an allowed time which is based on a standard time for the job, determined by time study. Each minute of allowed time is called a point. The standard number of points in an eight-hour day, of course, would be 480 points. The number of points allowed for a particular job is shown on the employee's work ticket. In order to know how much bonus he has earned in the course of the day, the workman has only to total the number of points allowed on the jobs which he has completed during the day, deduct the standard number of points from the total, and multiply the result by the value of his point. If at the end of the day he has completed all of the work assigned to him and the total of the allowed points is 540, then he has earned a premium of

60 points. If his hourly rate is 60 cents per hour, the value of his point is 1 cent. Therefore his premium is 60 cents.

When the employee receives the full value of the allowed points, the plan is really a special application of the principle of the Halsey premium plan in which the employee receives 100 per cent of any saving of the allowed time. In some cases, a certain percentage of the premium points is deducted as a bonus for the foreman.

Its advantages seem to be that it is readily understood by the men and they are able to compute their earnings easily. In connection with costs and payroll, probably it involves less office work than many other incentive plans. Under the plan, it is relatively easy to compare the operating efficiency of various shops. The fact that the workman receives any saving of the allowed time which he is able to make undoubtedly makes the plan relatively easy to install. Its incentive value is not as high as that of the Taylor or Gantt plan.

**Other Wage Incentive Plans.** In addition to the plans which have been noted, there are many other plans which apply the principles of wage payment in proportion to production, such as the Haynes "manit" plan, the Baum gain-sharing plan, the Barth premium plan, the Diemer bonus and premium plan, and numerous others. Many of them are of considerable value under certain conditions. Often they fail to meet the requirements of a good incentive plan, particularly with respect to the requirement that they have sufficient simplicity to permit the employee to understand them readily, and to compute his earnings easily.

An interesting plan which represents an attempt to attain a greater measure of justice in the adjustment and determination of wages, but which fails to meet the requirement of simplicity, is the plan which was developed by Mr. George Babcock at the H. H. Franklin Manufacturing Company.[1] In this plan not only is productivity taken into account, but such factors as the cost of living, the number of operations which the employee can perform, and numerous others.

**Extra Incentive Plans.** In addition to plans for wage payment in proportion to production there are many plans in operation in industry which indirectly offer incentives to the employee for increased production. In many cases, these incentives can be considered as extra wages in return for some extra service. In some instances they may represent an effort of the employer to meet what he considers to be the social responsibility of industry to its employees. Some plans are intended to increase the average length of the service of the employees. Others are intended to improve the morale of the organization by creating a feeling of greater security against the vicissitudes of old

[1] *Taylor System in Franklin Management*, by George Babcock.

age. In other instances still other motives may cause the development of such plans. In almost all cases, one of the primary reasons for their introduction is the desire to gain increased production by developing a stable, loyal organization, possessing a high morale.

The personnel director who fails to develop such an organization has failed in one of his principle functions. The personnel department is a service department for production. Maximum production cannot be obtained from the working force unless it is convinced that the management intends to deal fairly by it; unless labor turnover is sufficiently low so that the company can enjoy the highest possible level of skill and efficiency in the organization; unless the workers have that feeling of security and confidence which is necessary to high morale, and in turn to maximum production.

Examples of plans of this• nature are pension plans, length-of-service plans, attendance bonus plans, thrift plans, plans for the sale of stock to employees, vacation plans, and profit-sharing plans. Because such plans directly affect the development of better relations between the management and the working force, they are usually administered by the service section of the personnel department.

**Pension Plans.** The pension plan performs two functions—it recognizes faithful service and provides a certain measure of security against old age.

The employee's eligibility for a pension usually depends on two factors—his length of continuous service with the company and his age. In most concerns the employee must have served the company continuously for a period ranging from twenty to twenty-five years before he is eligible for a pension. Usually he cannot be retired before the age of sixty or sixty-five, except in unusual cases. In such instances retirement may take place at an earlier age, at the discretion of the board of directors or some high operating authority.

The operation of the plan rests with the management. While the management is primarily interested in promoting length of service, this is not always the sole motive. In a great many instances the management feels that the industry has a certain responsibility of caring for those who have given their working life to it.

The operation of a pension plan eventually may involve the annual expenditure of large sums of money. The determination of the pension risk involved, the amount of reserve to be set up, and similar questions require a technical knowledge of insurance principles which the average individual does not possess. As a result, it is unwise to attempt the introduction of a pension plan without competent actuarial assistance.

**Group Insurance.** Group insurance is intended to provide funds at the death of the wage-earner which will assist in holding the family unit together until it has adjusted itself to its changed economic condition. While the amount of the insurance received in any particular case is not sufficient to continue the wage-earner's income, it usually aids materially in defraying funeral expenses and may save surviving dependents from actual want, pending their adjustment to their changed conditions of life. The benefit to the employer comes from the greater peace of mind, stability and morale of the worker, which may be reflected to some extent in increased production, but probably to a greater extent in lower labor turnover.

The amount of insurance which the employee may receive usually depends on such factors as his length of service with the company and the amount of wages or salary which he receives. In the first case, the amount of the employee's policy may increase by a given increment for each year of service with the company, from some base policy value to some maximum policy value. To illustrate, at the end of his first six months' service with the company the employee might be entitled to a group policy for $300; at the end of his first year, a group policy for $600. Thereafter, the value of his policy might increase at the rate of $300 per year until it reached the maximum value of $3,000 at the end of the ninth year. In this manner the policy not only gives some measure of protection to the worker's family, but in addition it offers an inducement for continued service with the company. In the second case, the amount of the policy may not increase with length of service, but may depend on the man's wage or salary. As his salary increases, the amount of insurance to which he is entitled increases also. Under this plan there is an inducement for the key men to stay with the organization, which increases as they become more valuable to the company.

Usually the company pays a per capita premium for every man on the payroll. In most cases the employee does not bear any part of this expense.

**Length-of-service Plans.** This type of plan is one which is intended to promote, directly, increased length of service. In most cases the employee receives, as a bonus for length of service, a certain percentage of his base wages, which increases with length of service. The maximum bonus percentage varies between companies from 5 per cent to 10 per cent of the employee's wages. The minimum percentage varies from 1 per cent to 5 per cent. The length of continuous service necessary to earn the maximum bonus varies from two to ten years. The shorter periods probably are adopted on the assumption that the critical period in the employment of the average employee is within the

first two years of service. If he can be retained beyond that period, the danger of voluntary separation has decreased greatly, and with it the need for an increased bonus to promote length of service. In most cases the employee must have a certain minimum length of service before he is eligible to participate in the plan. Usually this minimum length of service is the only condition of eligibility.

Most length-of-service plans provide that bonus payments shall be made at the end of the year. Forfeiture of his right to a bonus may occur if the employee is absent or tardy more than a given number of times or if the employee quits the company. When reemployed following a voluntary separation, the employee is treated as a new employee in so far as his length of service is concerned.

**The Attendance Bonus.** The attendance bonus, as its name indicates, is intended to foster regularity of attendance. Its justification is the fact that production and its control are greatly facilitated if the employee is at his machine regularly. The company pays to its employees a bonus which is a certain per cent of their base wages, exclusive of overtime, provided they have worked the full number of hours for the pay period less any permitted allowance. The bonus is usually paid at the end of the pay period. It is not unreasonably deferred and is considered effective by many executives.

**Other Plans.** In addition to the plans which have been noted, there are many other types of plans for the payment of extra incentives. Some of these are designed to promote thrift by aiding the employee to accumulate savings by the deposit of a certain amount of his salary with the company at a very favorable rate of interest or by the investment in the stock of the company under favorable terms. In other cases they are intended to reward certain classes of employees for better than ordinary service, as in the case of the foreman's bonus.

While specific plans may be designed to produce certain desirable results, one of the primary motives for the introduction of extra-incentive plans is to give the employees some tangible evidence of the management's good will toward and interest in its employees, in the hope that by so doing they will be more loyal to the management and more inclined to cooperate with it for the best interests of all concerned.

# CHAPTER XXV

## PERSONNEL CONTROL—EMPLOYEE SERVICE

**The Nature of Service Work.** An interesting phase of personnel management is that which is called service work, welfare work, or by names having a similar meaning. It has to do principally with those activities which tend to improve the relations between the management and the operatives, the morale of the employees and indirectly their stability and production as a result therefrom. Accordingly, service management may be defined as that phase of personnel management which deals primarily with the problems involved in improving the relations between the management and the men, and the morale of the personnel. Within this general field come many activities, some of which have been treated in previous chapters, such as group insurance, pension plans, etc. In some instances, promotion may be a function of the service section. In addition, there are many others, such as the plant restaurant, recreation, athletics, the development of channels of communication between the management and the employees, and the handling of grievances.

If the employee feels that he is being treated unfairly by the management, if he is not at home in the shop and is not interested in its life, if he is troubled by financial difficulties, it is not likely that he will be a satisfied, permanent employee, or that he will produce the maximum of which he is capable. There is an economic justification for service work which is rather intangible, which cannot be stated easily in terms of money, but which is none the less real. Most employers have no desire to be engaged in continual strife with their employees. It is more pleasant and more satisfactory to know that your employees feel well disposed toward you and believe that you are dealing fairly with them. This desire for the good will of their employees is another important reason which has influenced many employers to introduce service work. Furthermore, the gradual enlightenment of the employer regarding his social responsibilities in the conduct of his enterprises is a factor. Usually, when he is convinced that such a responsibility exists, the average employer is ready to bear his reasonable share of it.

**The Service Organization.** In the personnel organization shown in Fig. 91, the service manager is an executive reporting to the personnel director. In order to handle the service functions effectively,

he should be a man of warm human interests who will have a real desire to promote the well-being of the employees as well as a man who is experienced in personnel work.

**Recreation.** Mr. Daniel Bloomfield states that "recreation is something more than play. It is an effective change of occupation."[1] It tends to ease the strain which results from the swift pace in modern industry. It aids in the elimination of fatigue poisons, thereby refreshing the energy of the worker, which is reflected in increased ability to produce. Furthermore, the interest which recreational activities arouse tends to hold the employees in the organization. Because of these very material advantages, some organizations employ a trained recreation director with whom the plant physician cooperates in the conduct of recreational activities.

The promotion of recreational activities should not be permitted to become paternalistic. The American workman resents any attempt to supervise his activities outside of working hours. Furthermore, too lavish expenditures may suggest the idea that the money might better be put in the weekly pay envelope. Those recreational activities are likely to be most successful which originate with the employees and which are supervised by them.

The extent to which recreational facilities are necessary varies considerably between companies. If the plant is located in a small town which does not offer adequate opportunities for recreation after working hours, then it may be necessary for the company to cooperate to supply the recreational deficiencies. On the other hand, if the plant is located in a large city, there are many activities to interest the worker after hours, and the distances from the workers' homes to the plant may be too great to make recreational activities after hours a practical proposition.

Probably in all plants there is some opportunity for limited recreation during the noon hour. If interdepartmental competition can be developed, the results may be very beneficial. Bloomfield points out that recreation of this sort has a democratizing influence. It tends to break down factions within the organization.

Following are some of the more common types of recreational activity.

(1) *Athletics.* Many concerns maintain large, well-equipped athletic fields for the use of their employees.

(2) *Motion Pictures.* Used both for amusement and education.

(3) *Rest Rooms.* Usually equipped with books and current literature of various kinds.

(4) *Club Houses.* There are a great many examples of these.

[1] *Labor Maintenance*, by Daniel Bloomfield.

The Curtis Publishing Company maintains a very good country club for its employees.

(5) *Playgrounds.* The U. S. Steel Corporation has established more than 125 children's playgrounds.

(6) *Music.* Some concerns maintain company bands, glee clubs, and similar musical activities. Often they have a certain amount of advertising as well as personnel value.

**The Plant Restaurant.** The plant restaurant has three important functions. It serves the workers with wholesome warm food at a minimum cost. It provides a social center where the men may gather during the noon hour. It provides a clean, decent place to eat.

Ability to get warm, properly selected food may affect the employee's productivity materially. A cold lunch of rich foods is hard to digest. For an hour or more after one has eaten such a lunch, one is likely to feel dull, lifeless, and sleepy. The danger of accidents increases and the ability to produce decreases.

It is not uncommon to see the men sitting around the tables in the restaurant discussing various subjects, after they have finished their meal. There may be card games in progress in various parts of the room. An opportunity has been provided for a desirable form of rest and recreation.

The provision of a decent place for the employees to eat their lunch sometimes has a considerable effect on labor turnover. This is particularly true if previous conditions have been bad. If one has had the experience of eating one's lunch with grimy hands while seated on a workbench littered with grease-covered tools and machine parts, one can appreciate that a washroom and a decent place to eat may add greatly to the worker's satisfaction with his job.

During the war, the British Ministry of Munitions made an investigation of industrial restaurants. A summary of the benefits which they considered resulted from the restaurant are listed below: [1]

*Direct benefits.*

Marked improvement in the health of the worker.
Less sickness.
Fewer absences and less broken time.
Diminished tendency to alcoholism.
Increased efficiency and output.

*Indirect benefits.*

Considerable time saved for the workers.
A salutary change from the workshop.
Greater contentment among the workers.
Better midday ventilation of the shop.
Increased recreational activities in spare time.

[1] Taken from a more complete discussion in Bloomfield's, *Labor Maintenance.*

The plant restaurant is a large shop development. Restaurants are not generally found in plants employing less than 500 employees. On the average, about 40 per cent of the total number of employees eat in the restaurant. As a result, the number of meals which can be sold in the small plant restaurant is not sufficient to make possible low-cost meals, which are essential to success. However, it is possible, even in the small plant, to provide a clean place to eat and to serve hot coffee at a nominal price.

Most industrial restaurants are run on the cafeterial plan to keep costs at a minimum. Even with a well-planned and well-managed cafeteria it is the usual experience that the restaurant will be run at a small loss. In most cases an attempt is made to sell the food at its cost plus the cost of the restaurant help. No charge is made for rent, light, and other overhead expenses. One reason for this practice seems to be that executives fear that if prices are high enough to cover all costs, the employees may feel that they are being exploited to the profit of the company. In many cases, the personnel department definitely expects to run the restaurant at a loss, feeling that any deficit incurred is a legitimate charge for employee service work.

**Employee Housing.** Under certain conditions, industrial housing may have an important relation to turnover. This may be the case in a large industrial city following a period of prosperity and great manufacturing activity, when there has been a considerable influx of workers drawn by the high wages which are offered. It may be the case in the small town in which a rapidly growing plant finds it necessary to bring in considerable additional labor. If a workman cannot get decent housing and create satisfactory home conditions at a reasonable cost, he will locate, at the first opportunity, where these necessities can be procured—other things being equal.

Regarding the importance of proper housing, Bloomfield says, "It is true that the two chief elements in labor maintenance are adequate wages and good working conditions; but the next factor is housing." [1] While some may question this ranking, its importance cannot be denied. The government's experience with housing during the War threw the close relation between housing and labor turnover into sharp relief. The War Department found that the instability of labor forces interfered seriously with the procurement of war materials. One of the most important causes of this instability was the inadequacy of housing facilities in many large industrial centers.

Proper industrial housing may be quite as important in times of peace as in war times, although the situation may not be so acute. If there is insufficient good housing reasonably adjacent to the plant,

[1] *Labor Maintenance*, by Daniel Bloomfield.

the employees may have to pay an exorbitant price for housing that is satisfactory. The excessive drain on the worker's income may mean a certain amount of privation in other ways. If he accepts poorer living quarters, the result may be unsatisfactory home conditions, loss of self-respect, lowered morale, dissatisfaction, and eventual separation from the company. The fact that large, well-managed organizations such as the U. S. Steel Corporation and the General Motors Corporation undertake ambitious housing programs indicates the necessity of proper housing for employees.

There is not sufficient data to indicate whether the investment involved pays a reasonable return directly, but the probabilities are that it does not. The difference between the actual return and a reasonable return must be considered to be an employee service charge.

The larger corporations usually organize separate housing corporations to handle their housing problems. These corporations survey local housing conditions to determine the availability of proper housing. They survey the employees to determine the character and extent of the demand for housing among their own employees. They work out plans for the easy purchases of homes and sometimes supervise the financial and construction details.

Any considerable discussion of financing methods is beyond the scope of this book, except to say that all service is intended to be given at cost. A reasonable rate of interest, 5 per cent or 6 per cent, is charged on unpaid balances. In some instances, advances are made by the company to the employee to enable him to make his first payment to the housing corporation. In the event that the employee leaves the company before his payments have been completed, the company may have the first opportunity to purchase.

The desire to provide good housing for its employees should not be permitted to lead the company into a paternalistic attitude on the subject. The demand for housing should flow naturally from the employees, with such publicity and stimulation of a general nature as may be necessary. Otherwise the company may lay itself open to the charge that its housing activities are merely a device to hold the employee to the company, weakening his bargaining position, and depriving him of his privilege to change jobs to his advantage. This is something quite different from an honest desire to make employment conditions so attractive that the employees will wish to stay with the company permanently.

While the small plant cannot undertake the solution of its housing problems on such a great scale, there are some steps which it can take, which are helpful and inexpensive. An employee of the personnel department can be appointed to look after the housing problems. He

can canvass the territory contiguous to the plant to determine the amount and character of the housing available. It can be made known that the personnel department will list all desirable rooms and apartments for rent and will bring them to the attention of its employees who are in need of housing. The department may be able to give advice regarding the purchase of homes.

**The Mutual Benefit Association.** The mutual benefit association is a form of private, social insurance. Its purpose is to provide the employee with some protection against the hazards of industry. The two most common benefits given by such associations are a measure of protection against loss of wages in case of disability, and the employee's funeral expenses.

______________________________ 192___

**DO NOT FOLD**

*I hereby apply for participation in THE PROCTER & GAMBLE COMPANY PENSION AND BENEFIT PLAN in effect on the date of this application and hereby agree to all of the terms and conditions thereof and consent and agree to be bound by all revisions and amendments of said plan which may be made hereafter.*

**FILL IN THIS SIDE ONLY**

*I was born at* ______________________________

*on the* __________ *day of* __________ __________, *and am* *single* / *married*
Month Year

*I hereby designate* ______________________________

*as my beneficiary to whom Death Benefits under said plan shall be paid.*

*I hereby authorize The* ______________________ *Company to deduct monthly from my wages all payments to be made by me under said plan.*

*I was employed at* ______________________ *on* __________ *192*___

*Passed by physician* ______________________ *192*___

*Approved* ______________________ ___*Mgr.*

*Courtesy—The Procter & Gamble Co.*

FIG. 112

A Benefit Association Application Blank

The organization of such associations may be justified on the grounds that the amount of the average employee's wages and his temperament do not make possible an adequate provision for such contingencies out of his wages; that the resulting financial worries cause discontentment and loss of morale.

In most cases, the idea of an employees' benefit association usually originates with the employer. His greater vision gives him a better appreciation of the problem. He has greater organizing ability and is in a better position to initiate the formation of such an organization. However, such an association should be essentially an employees' organization. As a result it is usually the case that after the organization has been perfected, the plant executives withdraw into the background as far as possible. The general supervision of the

Form A 120

Application No.________________ ________________Plant

# THE PROCTER & GAMBLE CO.

## PENSION AND BENEFIT PLAN

## APPLICATION FOR BENEFIT

Duplicate

**Note**—*The Physician's Certificate on the back of this Application must be properly filled out by your doctor before this Application will be accepted.*

Name of Applicant________________ Badge No.________

Department Employed ________________ Occupation________

Age ______ Single / Married / Widow / Widower ________________ Dependent Children________

Other Dependents ________________

How long in employ of this Company ________________

Of what other Benefit or Mutual Aid Societies are you a member ________________

Total amount of Benefits from these Societies ________________

Nature of injury / sickness ________________

First date unable to work ________ 19 ___ Time ___ A. M. / P. M. Shift ________

Date returned to work ________ 19 ___ Time ___ A. M. / P. M. Shift ________
(Leave blank if you have not returned to date)

Are you now unable to work because of your injury / sickness ________________

Name and address of your attending physician ________________
Name

________ Street No ________ City or Town ________ State

I certify that the above statements are correct and true to the best of my knowledge.

Signature of Applicant ________________
(Or other interested person)

Date ________ Applicant's Address ________________

*Applicant does not fill in below this line.*

REPORT OF TIME KEEPING DEPARTMENT

Date of first absence ________ Time ___ A. M. / P. M. Date returned to work ________ Time ___ A. M. / P. M.
(Leave blank if not returned to date)

Remarks________________

Date received ________ 19 ___ Signature________________

Date returned ________ 19 ___ Department ________________

WAGE INFORMATION TO BE FURNISHED BY THE PLANT PAY ROLL DEPARTMENT

Applicant's weekly wage at the time of disability was ________________

Applicant's weekly wage at the time of disability was (75% Basis)________________

Date received ________ 19 ___ Signed________________

Date returned ________ 19 ___ Department ________________

*Courtesy—The Procter & Gamble Co.*

FIG. 113

AN APPLICATION FOR BENEFITS

association should be vested in a committee elected by and from the employees. A member of the financial organization may be appointed to the committee by the management to advise in the administration of funds and other financial matters. It may be convenient to appoint a member of the personnel department to act as executive secretary because of his contacts with the personnel and his availability during working hours.

The organization of a mutual benefit association usually is preceded by a campaign of education among the employees to familiarize them with its purposes, functions, and desirability. After a satisfactory groundwork has been laid, the next step may be to explain the details of a tentative plan to the employees through the medium of the house organ and to elect a committee of employees to perfect them. This committee should work up a constitution and by-laws for presentation to the employees. The final step in organizing may be to hold an election among the employees for the adoption of the constitution and by-laws and the election of officers.

Membership in such associations usually is optional. All regular employees are eligible. In some cases they are eligible only after a satisfactory examination by the company physician. Membership dues usually are small, ranging from twenty-five cents to one dollar per month, deductible from wages. In almost all cases membership ceases when employment terminates.

**The Promotion of Thrift.** Some executives feel that the thrifty employee is the more stable, dependable, and contented employee. Accordingly, there are numerous examples in industry of plans which are intended to develop the habit of thrift.

Like most service activities, participation in a thrift plan usually is voluntary. If the employee elects to join the plan, he must deposit a small percentage of his salary each week. In some cases the decision as to the percentage to be deposited rests with the employee. Sometimes there is a minimum percentage for each salary range. The employee receives more than the current rate on bank deposits. A large food-packing concern in Cleveland pays 5 per cent per annum on all savings up to $2 per week, and 6 per cent on all savings above this amount. There are instances where the company has agreed to make a deposit to the employee's credit equal to the amount which he deposits. Usually there is a provision that the total of such credits shall not exceed a certain per cent of the company's net income.

Another type of plan which tends to promote thrift is the stock sales plan. The purpose of this type is to facilitate the purchase of the company's stock, common or preferred, as the case may be, in order to promote thrift and an increased interest among the employees in the

# STOCK PURCHASE AGREEMENT

MEMORANDUM OF AGREEMENT between THE FIRESTONE TIRE & RUBBER COMPANY, an Ohio corporation.

Party of the First Part (hereinafter called the "Company"). and ........................................................
Party of the Second Part (hereinafter called the "Employee").

WITNESSETH:

WHEREAS, it is considered to be mutually desirable for the said Company and its employees that its employees doing meritorious work should become stockholders of the Company; and

WHEREAS, for the purpose of carrying out such plan, the Company has authorized the sale to such employees of a portion of its common stock at a price materially below the actual value thereof, upon certain terms and conditions of payment and surrender of contract hereinafter named; and

WHEREAS, the Employee desires to become a purchaser of 2 shares of such capital stock, upon such terms and conditions;

THEREFORE, IT IS AGREED AS FOLLOWS:

1: The Employee has this day subscribed for 2 shares of the common capital stock of the Company, and agreed to pay there for the sum of $200.00, and, to secure said payment, has deposited with the Company, his certificate for the said shares of stock. The unpaid portion of the purchase price shall bear interest at Six per cent. (6%) per annum.

2: The Employee further agrees to pay, on account of the principal and interest of the unpaid balance of said purchase price, at such place as the Company may hereafter designate, $1.00 per week beginning on the first regular payday after completing 30 days of employment, until the whole of such purchase price, plus the interest above specified shall have been paid. The Employee may at any time make additional payments in excess of the above minimum payments.

3: This agreement shall be cancelled at any time upon (a) failure of Employee to make the minimum payments as hereinabove provided, unless the time for making such payments is extended by the Company; (b) any attempt of the Employee to sell his stock or his contract or any interest therein or rights thereunder; (c) resignation or dismissal of the Employee before the expiration of five (5) years from date. (Women, who, after having been in the employ of the Company for two or more years, shall leave to be married, may, upon being married within three months after leaving the Company's employ, have the privilege of continuing their payments on the same terms and conditions as if they remained in the Company's employ.) If this agreement shall be cancelled, the Employee shall receive from the Company the full amount of all payments made by him upon this agreement, with interest thereon at Six per cent. (6%) per annum from the date on which each payment has been made, but no dividends; nor will he be charged interest on his deferred payments. An additional sum shall also be paid the Employee (pro-

vided the market price of the stock is then in excess of the price at which the Employee purchased) upon the following schedule:

Cancellation in less than one (1) year from date, no additional payment;

Cancellation after one (1) year and less than two (2) years, ten per cent. (10%) of the difference between the price at which the Employee purchased and the market price;

Cancellation after two (2) years and less than three (3) years, twenty-five per cent. (25%) of the difference between the price at which the Employee purchased and the market price;

Cancellation after three (3) years and less than four (4) years; forty-five per cent. (45%) of the difference between the price at which the Employee purchased and the market price;

Cancellation after four (4) years, seventy per cent. (70%) of the difference between the price at which the Employee purchased and the market price.

The market price shall be the average bid price, as quoted in the leading Cleveland morning newspaper on the Tuesday before the date of cancellation (the above being now considered the most reliable source of information). If later a more reliable source is available, the Company reserves the right to adopt it.

Instead of taking over the stock subscribed for herein on the above basis, the Company reserves the right in case of cancellation, to sell the stock in the open market and to pay Employee such percentage of the price received above the price at which this subscription was made, as stated in the above schedule.

If, through accident, sickness or other cause the Employee shall at any time be unable to make his payments as above required, he shall apply to the Employees' Stock Department, which will be located in the Firestone Park Trust & Savings Bank (or at such other place as the Company may hereafter determine), which Department will extend the time of such payments in such cases as they shall find the circumstances warrant and justify; and the decision of such Department in such matter shall be final.

4: In consideration of the reduced price and favorable terms of payment at which this subscription agreement is accepted by the Company, it is further agreed that, unless this agreement shall be previously cancelled as hereinabove provided, the certificate for the full number of shares subscribed for shall remain with the Company, for the full period of five (5) years, whether the stock shall have been previously paid for or not. If at the end of the five-year period all payments provided for herein have been made, the certificates of stock shall be delivered to the Employee as his unconditional property; otherwise the certificates are to remain with the Company until all amounts due on this agreement have been paid, whereupon certificates shall be delivered to the Employee as his unconditional property.

5: In case of death or total disability of the Employee within five (5) years from date, or while the agreement is in force after that date, the following disposition of his interest therein shall be made:

*Courtesy of the Firestone Tire and Rubber Co.*

FIG. 114

The First Page of an Employee's Stock Purchase Agreement.

success of the company. In such cases, it is hoped that ownership of stock will produce a more cooperative spirit and a desire to give the greatest possible production.

**Channels of Communication.** In the early stages of the development of our industries, when industrial units were smaller, there was often an intimate contact between the owner and manager of the industry and his employees. While the problems of management were simpler, the employee had a better appreciation of them because of his closer contacts with the owner-manager. It is not implied that the early days of the development of American industry were entirely free from labor troubles, because such was not the case. However, where owners had a sympathetic interest in their employees, they were usually rewarded by interested cooperation growing out of the closer contacts. Even today there are a great many small shops in which the employees have a sympathetic interest in the success of the business, due to such close contacts.

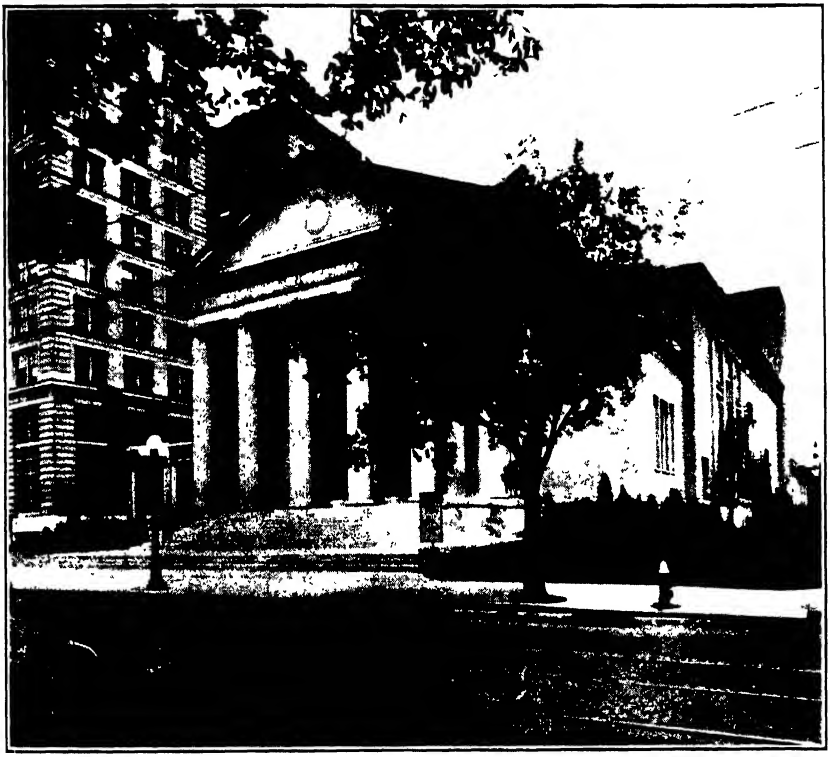
In many of our large industries the stockholders have only a profit interest in the business. The general management may be located in some city which is at a considerable distance from the plant. The officers and high executives of the company are merely names to the employees. They, in turn, are chiefly interested in maximum wages for minimum effort. For these reasons, it is desirable, in many concerns, that better contacts and means of communication between the management and the employees be established.

**Suggestion Systems.** The suggestion system is one which is intended to facilitate the making of complaints or suggestions by the employees, regarding the conditions of employment or other phases of the management of the plant.

The mechanism of the suggestion system consists of the suggestion boxes located at strategic points throughout the plant, standard blanks for making suggestions placed near each box, and some regularly organized committee for considering suggestions. Publicity should be given to the aims and objects of the system and the procedure for submitting suggestions.

In most cases, a committee for considering and grading the suggestions is selected by the management from among the older employees, together with certain executives appointed because of their technical or managerial knowledge. In some cases, the employees may be permitted to elect the employee members of the committee.

The suggestions, on the standard forms, are collected from the suggestion boxes at regular intervals. They are then graded by the committee with regard to their value to the company. They may refer to methods for increasing production, bettering working conditions



*Courtesy—National Cash Register Co.*

PLATE 28

A Company School

in the plant or any other subject regarding which the employee thinks he has a good idea. No suggestion should be pigeonholed regardless of how little value it may have. Unless this is accepted as a basic

Form No. C-933

**THE PROCTER & GAMBLE CO.**

**Suggestion No. 1521 -A** **Ivorydale, Ohio** ______________

**THE PROCTER & GAMBLE CO.**

**Gentlemen:**

**I desire to respectfully submit the following suggestion:**

**Payroll Badge No.** **Very truly yours,**

______________ **Signed** ______________

**Suggestion No. 1521 -A**

**In case you do not wish to sign your name, detach and preserve this slip:**

*Courtesy—The Procter & Gamble Co.*

FIG. 115
A Suggestion Blank

principle, the system will gradually die from lack of interest. All suggestions should be acknowledged with a statement of the action taken by the committee and the reasons for such action.

The employee should be paid for those suggestions which are of value to the company. In most cases there is a definite scale of rewards for different grades of suggestions. The difficulty with this method

is that the reward may be entirely inadequate with regard to the value of the suggestion. Where this is the case the effect on the employees in the shop may be negative because of the apparent injustice. If the system is to have the greatest success, the amount of the reward should have some definite relation to the value of the suggestion, particularly where its value can be estimated with reasonable accuracy.

In addition, the names of those who have made valuable suggestions should be printed in the shop paper in order to take advantage

**THE PROCTER & GAMBLE CO.**

SUGGESTION COMMITTEE

ACKNOWLEDGEMENT OF SUGGESTION

RECORD NO.__________ IVORYDALE, O.__

M______________________

We acknowledge the receipt of your Suggestion No.__

for which we thank you. It has been referred to Mr.__________

for investigation. You may bring to his attention any further information you may have concerning your idea.

You will be advised of final disposition just as soon as a decision is reached.

Very truly yours,

SUGGESTION COMMITTEE

__________________ Chairman

*Courtesy The Procter & Gamble Co.*

FIG. 116

A SUGGESTION ACKNOWLEDGMENT

of the spirit of competition and the pride of accomplishment. In many cases, of course, the only reward that can be given is that of honorable mention.

Finally, all suggestions which have received honorable mention should be recorded on the employees' history cards and should have consideration in connection with promotion.

**Handling Grievances.** Some plants which do not have an organized suggestion system or which do not care to handle grievances through it, have a regular procedure for the consideration of employee grievances. There are certain advantages to having such a procedure. It is not uncommon to hear some managing executive say that the door of his office is always open to any employee who thinks that he has a grievance. While such statements are almost always made in good faith, they rarely mean much. The employee is diffident about going

to the office of an important executive with a grievance which in itself is not of great importance. Obviously, if any large number were to do so the executive's time would be absorbed largely in listening to troubles. Furthermore, the practice of leaving the adjustment of employee grievances to the foreman is not satisfactory. In many cases he has a personal interest in the grievance. In any event, he is too busy with his usual supervisory duties to seek out the cause of the maladjustment and to see that it is properly corrected. As a result of such methods, many petty grievances are overlooked or poorly adjusted. Individually, they may not be important. In the aggregate, they may be a considerable cause of irritation among the workers, low morale, ill-feeling and underproduction.

In many plants the procedure for handling employee grievances is somewhat as follows. The employee first takes up the grievance with his foreman or department head. If he fails to get satisfaction from the foreman, he can arrange an appointment and present his case to the personnel manager or service supervisor, who may endeavor to adjust the matter with the department head. If he is still dissatisfied, he can present a written appeal to the shop superintendent or general manager. In some instances the employee can carry his case, by written appeal, to the president or the board of directors, with whom the final decision always rests.

**Employee Representation.** A system of employee representation is one in which matters affecting the interests of the employees are considered, and recommendations to the management pertaining thereto are formulated, by a committee of representatives, elected by the employees from among their own numbers. This committee may meet independently or with not more than an equal number of representatives of the management. Such recommendations have legislative status, but not executive status, unless approved by the management.

The purpose of the system is to provide a formal channel through which the needs and desires of the employees can be expressed, and through which the management can enlist the cooperation of the employees in the solution of management problems affecting their mutual interests.

Any system of collective dealing, to be successful, must rest on a sincere desire on the part of the management to cooperate with its employees. If the purpose of the plan is to make the employees feel that they are getting a large measure of democracy in management while actually they are not, then the plan is doomed to failure. The employees are quick to sense such a situation.

Before any such plan can be put in operation it should be preceded by a considerable campaign of employee education in industrial eco-

nomics. Unless this is done, the operation of the plan may be hampered by many economic misconceptions on the part of the employee representatives, which can easily cause its failure.

Simplicity is most decidedly a virtue in connection with employee representation. If an undue length of time must elapse before the employees can get action on recommendations, because of unnecessary red tape, there is likely to be a loss of interest in the plan. There is danger of dissatisfaction with the slowness with which unsatisfactory conditions are adjusted. Possibly suspicion may be aroused that the plan is intended to give a semblance of action without any real relief. The tendency in most plans is toward greater simplicity.

Employee representatives must have absolute immunity from discrimination by the management because of any action taken or opinions expressed in the discharge of their representative duties. Very often this guaranty is written into the constitution of the plan. Without such a guaranty it may be difficult to get frank expressions of opinion from the employee representatives, the confidence of the employees, or their cooperation.

In order to get as widespread interest in the plan as possible, it is usually provided that all employees are eligible to vote in elections and to serve as representatives, with some minor restrictions as to age, length of service, citizenship, etc. In all cases, the election of employee representatives should be under the supervision of the employees, in order that they may have no feeling that the elections are fixed so that only representatives favorable to the management are elected.

The scope of the shop committee's activities should not be restricted. If they wish to consider management matters which are not directly connected with wages and working conditions, the management should cooperate with them in such consideration. If their activities are restricted, the employee representatives may feel that there is no real basis of cooperation; that the management is endeavoring to confine their attention to those subjects which are considered safe.

Finally, all recommendations from the shop committees should receive prompt action from the management. If for any reason it cannot approve a recommendation, it should immediately return the recommendation to the committee with a complete statement of the reasons for its veto.

**Types of Employee Representation Plans.** There are two types of employee representation plans, the bicameral and joint-committee types. In the bicameral type the elected representatives of the employees and the represenatives of the management meet as separate committees. The advantage of the separate committee is that there is no danger that the employee representatives will be overawed by the presence of

management representatives, and as a result it is more probable that frank expressions of opinion will be obtained. Recommendations, originating with either committee, which affect the interests of the employees, must be presented to the other committee for consideration before being forwarded to the final authority for approval. In some plans of this type, the names of the committees are taken from similar legislative and executive bodies in our federal government to suggest some analogy between our political democracy and industrial democracy. For instance, the employees' committee may be called the House of Representatives, the committee of management representatives the Senate, and the committee of higher executives, which is the final authority, the Cabinet. To illustrate the course of recommendations under this type of organization, suppose that the management committee, composed largely of foremen and other shop executives, decides to make some recommendation to the general management regarding piece rates in the shop. Before this recommendation could be approved finally it would be necessary to submit it to the employees' committee. In the event that the latter committee did not approve it, the recommendation would be returned to the management committee with suggested changes. It might be necessary for the recommendation to be submitted to both committees a number of times before their views could be harmonized. After the recommendation had received the approval of both committees, it would be forwarded to the final authority. This final authority might be the executive committee of the plant, the president of the company, or even the board of directors. When the recommendation received the approval of the final authority it would become an executive order.

In the joint-committee type of employee representation the representatives of the employees meet with not more than an equal number of representatives of the management. Any recommendations approved by this committee go directly to the final authority for approval. It is claimed that this type of organization facilitates action on employee recommendations in that the red tape of passing bills back and forth between separate committees is eliminated. After the employee representatives have become convinced of the honesty and fairness of the management, there is no difficulty in getting a free expression of opinion from them. Usually there is a provision that the employee representatives may withdraw for caucus if they so desire.

Fig. 117 shows an organization for employee representation which might be suitable for a large corporation operating a number of plants. The various management committees are shown in dotted lines to indicate that in a similar organization of the joint-committee type the employee and management committees would be combined.

**The Growth of Employee Representation.** Data collected by the National Industrial Conference Board indicate that in 1919 there were approximately 391,000 employees working under employee representation. In 1924 the number had increased to approximately 1,100,000 workers. This remarkable growth is due to a number of influences. One of the most important is the influence which governmental authorities exerted in the period of government control during and immediately following the War. In addition, there are other reasons, but their discussion is outside of the scope of this book.

**The Field of Usefulness of the Shop Committee.** A number of surveys seem to indicate that very few plans for employee representation are to be found in plants employing less than 250 employees. The greatest number seem to be in plants employing between 500 and 5,000

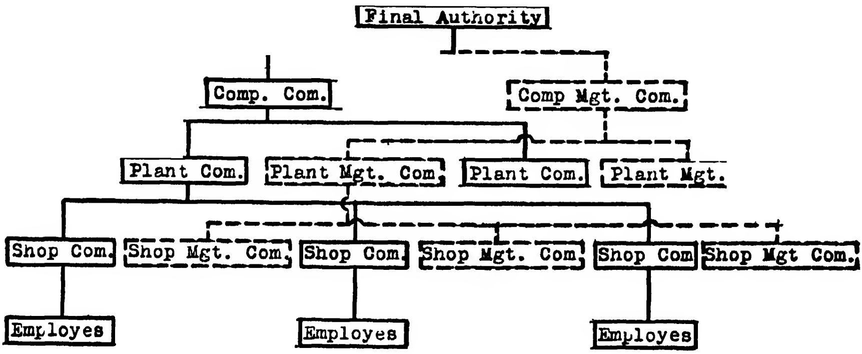



FIG. 117
A SHOP COMMITTEE ORGANIZATION

employees. One reason for this is that in the very small plants there is sufficient personal contact between the employees and the management, so that more formal channels of communication are not necessary.

**The Results of Employee Representation.** The majority of executives who have plans for employee representation in operation in their plants are unable to point, with any assurance, to tangible benefits from the plans. However, they are almost unanimously agreed that where such plans are operated intelligently and honestly they result in increased cooperation from the workmen and increased morale in the whole organization. Of course there are instances where the management can point definitely to tangible benefits such as decreased turnover, increased production, direct assistance in setting production standards, and many other advantages. The opinion seems to be that the increased morale and the better cooperation developed is well worth the time and expense required for the operation of a system of employee representation.

# CHAPTER XXVI

# PERSONNEL CONTROL—EMPLOYEE EDUCATION AND TRAINING

**The Function of the Education Section.** The education section of the personnel department is partially the result of the necessity for developing a supply of skilled workers or executives and the realization of managers that the mental stimulation of the whole working force, together with their general upgrading, will confer, indirectly, considerable benefits on the company.

These benefits, while intangible, are none the less real. The provision of opportunities for self-development tends to stimulate ambition, particularly among the younger employees, which induces greater application to the job and more intelligent performance of duties. Even the older employees may be stimulated to become more effective workers, due to the more effective competition of the younger workers. A better understanding of the management's problems, valuable suggestions for the better performance of specific jobs or the operation of the plant, and many other benefits, often flow from the activities of a well-organized education and training section.

Undoubtedly it can do much to create conditions which will tend to reduce labor turnover. There should be a rational connection between its work and the promotion policy of the company. The creation of a better understanding of the company's problems in itself tends to develop a better morale in the organization and therefore to react favorably on labor turnover.

Because of the greater realization by the more progressive plant executives of the social responsibilities of industry to its employees, there is a greater tendency to cooperate with public educational authorities in the education of minors in industry through part-time schools, continuation schools, and other means.

**Educational Activities.** By plant educational activities is meant those activities of the education and training section which do not relate to training for a specific job or craft, which are concerned primarily with the general education and development of the employee. Such activities include the operation of company schools, cooperation with public educational authorities in the conduct of part-time and continuation schools, the publication of the shop paper, the maintenance of

company libraries, cooperation with employees in connection with correspondence courses, and similar work.

**The Company School.** The company school is intended to provide the ambitious employee with means for his further development. Such schools are maintained at the company's expense, for reasons which have been noted previously. The courses offered usually do not train for any specific job or craft, but are such as to make the employee more valuable to himself and to the company in his work. Obviously the curriculum must be suited to the needs of the company, and therefore will vary considerably between companies. Some courses which are commonly offered are English, shop mathematics, mechanical drawing, elementary metallurgy, and elementary courses in shop organization and management.

In some cases, the company school has been developed to a considerable extent, as in the case of "Goodyear University," maintained by the Goodyear Tire and Rubber Company. In this particular case, it is possible for the employee to receive instruction in many subjects which are usually considered of collegiate rank. However, a plant educational project of such magnitude is possible only for a large corporation employing many thousands of employees.

In addition to the regular courses in the school, outside authorities may be brought to the plant to address the employees during the noon hour on various subjects related to industrial economics.

In plants which employ large numbers of foreign-born workers, Americanization work is an important phase of the work of the education and training section. In addition to training in English, reading and writing, and education in the ideals of our democracy, the foreigner is coached for his naturalization examinations. The section aids greatly in the work of Americanization by urging foreigners to qualify for citizenship as rapidly as possible.

**The Shop Paper.** The shop paper has three important functions. It offers a channel of communication between the management and the employees; assists in the development of the social life of the factory; aids in the education of the employees in the internal economics of the business.

Because of the nature of the first two functions, the publication of the shop paper may be placed under the service section of the personnel department in a great many cases. However, because of the importance of educating the employees in industrial economics and the important part which the shop paper can take in such work, a better place for its publication may be under the supervision of the education and training section.

The shop paper can serve as a channel of communication between

the management and the employees for the reason that it offers an opportunity for the presentation of the management's viewpoint on any matters affecting the employee's interests. Furthermore, it should be a means by which worth-while suggestions and criticisms of plant operations can be presented by employees.

A common use of the shop paper, and one which is often carried to extremes, is the development of the social life of the plant. Interesting occurrences in different shops or departments, plant athletic activities, interesting news regarding the older and better-known employees in various departments, tend gradually to interest the employee and fuse him into the life of the shop. When the life of the shop becomes an integral part of the life of the employee, he is usually a steady, permanent employee.

A field for the shop paper, which also tends to accomplish many of the purposes mentioned, is the education of the employees in what may be termed the internal economics of the business. One of the great personnel problems in modern industry is the employee's lack of knowledge of the relation of his job to the manufacture of the finished product. He has little or no conception of the relation of the work of other employees to the work that he is doing. Articles printed in the shop paper dealing with the product, its construction, and the processes necessary to the manufacture of the various parts which enter into it; articles showing methods of selling the product; articles dealing with the methods of management and their relation to the worker—all tend to give the employee a greater appreciation of the problems of the management, the relation of his job to the manufacture of the product, and a greater interest in his job. The result usually is better and more intelligent cooperation.

In addition to the field of education in industrial economics, the shop paper can be helpful directly in assisting the workman to develop himself generally or for his job. In some instances, short courses of study dealing with such subjects as shop mathematics are run in the shop paper.

**Plant Libraries.** In order to afford greater opportunities for self-development, many plants maintain plant libraries. Often such libraries are supervised by a paid, trained librarian. Where this is the case, the library may serve additional function of keeping the various plant executives informed regarding interesting articles in current magazines bearing on developments in their particular fields. New books and magazines are digested by the librarian and notice of such articles is sent to the various executives who might be interested.

In some cases there is a reading-room for employees in connection with the plant library to afford the employees an opportunity to read

during rest periods or during the noon hour. Sometimes books are loaned by the plant library to employees.

The plant library often is operated in cooperation with the city library system.

**Correspondence Courses and Night Schools.** Some companies encourage their employees to take correspondence or night-school courses on the theory that anything which tends to upgrade the employees reacts to the benefit of the company. As an incentive to take and complete such courses, the employees should be encouraged to report their enrollment to the personnel department, which enters the fact on their history cards. An effort should then be made to have the completion of the courses, with the final grades, reported so that they also may appear on the card. It should be understood generally that this information is a part of the basis for promotion.

**Other Educational Activities.** The plant bulletin board can be used in connection with plant education to a greater extent than is usually the case. For a long time it has been used to display posters promoting safety work. Similarly, it can be used more extensively to present graphically many facts relating to personnel relations or the general problems of management.

Along the same lines of a visual presentation of plant economics, some concerns are using motion pictures to present interesting information relating to the plant and its processes. As previously pointed out, much of the pride of craftsmanship has been lost because the employee performs but a single operation in a complex manufacturing process, with little or no knowledge of the relation of his work to the production of the finished product. If he can visualize the importance of his job in the whole scheme of production, much of his lack of interest in his job can be overcome.

**Shop Training.** By shop training is meant that work of the education and training section which has to do with the training of employees for specific jobs or crafts. The nature of the training methods and the extent to which they are developed in a particular plant is a function of the training needs of that plant. In some plants, little or no training may be required for new employees. In others, it may be necessary to develop semi-skilled workers for certain jobs, and in addition to develop and maintain a supply of skilled craftsmen of various kinds.

**Training on the Job.** In this type of training, the employee receives instruction in the performance of his job from an experienced workman who is regularly designated for this work, or from the foreman. Instruction is given from time to time while the new employee is regularly working at his job. The difficulty with this type of training is that it is hard to find a workman who has the combination of skill

and teaching ability which is necessary to the satisfactory performance of this function. Furthermore, training work of this type is likely to be poorly organized and to suffer as a result.

**Instruction by Training Supervisors.** This method is somewhat similar to the preceding method, except that a corps of skilled instructors who devote their whole time to the training of employees is developed. Certain of these men may be assigned to a department or a group of departments. Because of the fact that they are specialized in training work, the training of new employees is likely to be better organized and to be carried on more effectively than under the preceding system.

**The Understudy System.** The theory of this system is that for every job in the plant there is a man who is being trained to take that job when it becomes vacant. When the job becomes temporarily vacant, the understudy is transferred to the job to carry it on until the regular operative returns. To be really successful, there should be a well-worked-out plan of promotion. However, care should be exercised that the method is not so rigid that other employees who are entitled to promotion to the particular job in question are deprived of legitimate promotional opportunity.

A variant of this idea is the Gilbreth three-position plan of promotion. Under this plan, each employee in the plant is considered to be holding three positions. The first is the job from which he has been promoted. He is expected to train the man who has taken his former job for his present job. His second position is the job on which he is at present employed. His third position is the job to which he expects to be promoted. It is expected that he shall make every effort to train himself for this job so that he can step into it when the opportunity offers.

**The Flying Squadron.** This method, made famous by the Goodyear Tire and Rubber Company, is intended to provide a source of executive material, familiar with the various operations in the plant. A corps of men, picked for their possible development into executives, is maintained for use in any department in the plant in which an emergency need for labor arises. Because of their varied experience, a supply of labor skilled in all phases of the work is developed. In addition to this varied training, the members of the flying squadron receive some organized instruction in the principles and practices of industrial management.

In addition to developing a source of executive material, a mobile force of workmen, skilled in all phases of production, is a considerable aid in maintaining and balancing production between departments.

**The Apprentice System.** The modern apprentice system differs from the guild apprentice system in at least two important ways. First, the individual contact with and competent instruction under a skilled master of the craft has disappeared. With it has gone some of the inspiration to acquire craft skill. In the second place, modern industry requires that journeymen be created with greater speed and efficiency than was possible under the unorganized methods of the guild apprentice system.

An apprentice system is a system of training intended to provide the apprentice with sufficient skill and knowledge of his craft to permit him to handle, in a satisfactory manner, the work of that craft under ordinary conditions and supervision.

The maintenance of an adequate supply of skilled journeymen has been rendered difficult in many crafts for a number of reasons. Many journeymen are forced to get their training by casual and irregular contacts with the work of the craft in different shops, due to the fact that there is an increasing number of plants which have discontinued their apprentice training courses. One reason for discontinuance is that concerns which do not wish to bear the expense of apprentice training hire the journeymen which other firms have made. A partial remedy for this is to make the apprentice course pay its way by routing as much productive work to the apprentice shop as possible. Another remedy is to hold the newly created journeymen by the application of a proper wage and promotion policy. Another cause for the failure of some apprentice courses is the fact that no account is taken of the varying abilities of apprentices. The apt apprentices can progress no faster than those who are less apt. Many boys are discouraged by the fact that the period of apprenticeship at low wages is unnecessarily long. They are likely to quit the course and go to another plant on some regularly productive job at a higher rate of pay. Poor training methods will detract from the effectiveness of the apprentice course and will act to discourage apprentices from completing it. Finally, the methods of selecting apprentices in most cases are unsatisfactory. In many instances, selection is based chiefly on the fact the boy's father is a skilled mechanic with the company. No attempt is made to determine the extent to which certain innate capacities, necessary to the acquirement of a high degree of skill in the craft, are present in the candidate for the course.

While any extended discussion of modern industrial apprentice systems is not possible in this book, it may be desirable to point out a few of the principal requirements of a good apprentice system. In the first place, the aims and content of the apprentice course should be definitely formulated and stated in an apprentice manual in order that the apprentice may know exactly the nature of the work in which he

must perfect himself. Such a manual permits the apprentice to determine for himself the progress that he is making and as a result tends to maintain his interest in the course. Provision should be made for advancing the apprentice in the course as rapidly as his progress will permit. As he becomes eligible for advancement, his rate of pay should be adjusted accordingly as an incentive and a reward for perfecting himself in his craft. Eligibility should not depend entirely upon serving a specified length of time in each apprentice grade. It should be determined largely on the basis of proficiency, which in turn should be determined by job tests, oral examinations, and the ratings of instructors.

As stated previously, as much production work should be done in the apprentice shop as possible. Such work gives the apprentice more practical experience in the work that he must perform as a journeyman, maintains his interest in the work of the course, and reduces the expense of training apprentices.

**The Vestibule School.** The vestibule school differs from the apprentice school in that the former trains for a specific job while the latter trains for a craft. To illustrate, in the latter we may train apprentices for the craft of machinist while in the former we may train applicants to become lathe hands, milling-machine hands, etc.

The apprentice course may require a number of years for its completion. Lathe hands can be trained in the course of a few months. In addition, the vestibule school may be used to give the new employees a short course of training for semi-skilled jobs.

The advantage of the vestibule school is that new workers on semi-skilled jobs or skilled jobs of a specialized nature are brought to a reasonable efficiency in a relatively short space of time. Inasmuch as the learning period is likely to be the critical period that determines the permanency of the worker, the introduction of the vestibule school may have some beneficial effects on labor turnover. In addition, the training of the new employee is effected with less interference with the normal production of the shop. Finally, the vestibule school has the advantage that a supply of semi-skilled labor can be created in a relatively short time during periods when there is a shortage of such labor and manufacturers are bidding for the available supply.

# CHAPTER XXVII

## PERSONNEL CONTROL—DETERMINING THE CAUSES OF IMPROPER LABOR RELATIONS

THE causes of improper labor relations often are intangible. Therefore it is the more important that there be adequate methods and instruments for locating such causes. Unless they are located and proper action taken, there can be no hope that the quality of the company's labor relations will be steadily improved. The two most important methods are the analysis of the causes of labor turnover through the instrumentation of the labor-turnover record and the labor audit.

**The Nature of Labor Turnover.** Mr. Sumner H. Slichter defines labor turnover as "all terminations of employment in the force regardless of cause." [1] Those who take this view feel that all separations from the payroll involve cost to the employer, the employee, and the public. Therefore all should be included as turnover. A new employee requires more than ordinary supervision. His production, for a considerable period, is below normal. For this reason there is a certain amount of overhead expense which is not absorbed by the production from his machine. In addition, there will be more than a normal amount of scrap until he acquires average skill and efficiency. In some cases he must receive special training before he can be placed on a productive job. Furthermore, there is the pro-rata cost of operating the employment department. These and other items are a measure of the employer's investment in the employee, which is lost when he is released. Separation involves some costs to the employee, as there is some time in which he is out of work while finding a new job. He not only loses the wages which he would have earned, but may be forced to draw on his savings. From the viewpoint of society, there is a social cost in that the new employee often has a higher accident rate than the seasoned, skilled employee. There is likely to be some loss of morale if the period of unemployment, while he is finding a new job, is at all extended. These costs occur whether or not it is the intention to replace the employee later. Inasmuch as one of the primary functions of the personnel department is to reduce labor turnover and its attendant costs, it would seem that all separations should be considered as labor turnover.

On the other hand, there are those who feel that only employees

[1] *The Turnover of Factory Labor*, by Sumner H. Slichter, p. 3.

who are to be replaced should be considered as labor turnover. Mr. Paul H. Douglas defines labor turnover as "simply the number of men hired by a given business unit to take the places of the men who have left. Turnover does not begin until replacement occurs." [1] In other words, during a seasonal decline in operations when many employees are being laid off, a measure of turnover based on this concept might show that no turnover had taken place. Those who advocate this view feel that, while separations may be satisfactory when the working force is increasing, they give erroneous figures when the force is decreasing. The organization is charged with losses over which it has little or no control.

**Measures of Labor Turnover.** In addition to the above views, there are many other concepts of labor turnover which are more complex. As a result, there are many different measures of labor turnover in use. In most plants the measure of turnover is a ratio or percentage determined by the relation of separations or replacements to the average number on the payroll or the average working force for the period under consideration. A committee of the National Employment Managers Conference, held at Rochester, N. Y., in 1918, recommended that the "percentage of labor turnover, for any period considered, is the ratio of the total number of separations during this period to the average number of employees on the force report during that period." The force report gives the number of men actually working each day, as shown by the attendance records. Their formula is

$$T = S/M$$

where S is the total number of separations for the period. and M is the average number actually working each day throughout the period. On the other hand, Mr. Paul H. Douglas suggests the formula,

$$T = R/M$$

where R is the number of replacements and M is the average number on the payroll. This figure is obtained by averaging the number on the payroll at the beginning and end of the month. In addition there are numerous other formulæ for computing turnover.

Scott and Clothier have summarized the various arguments regarding these factors in computing turnover as follows: [2]

In favor of using replacements:

(1) On an increasing payroll, separations are not a true measure of labor turnover, for separations at this time are a direct saving to the firm, as a general rule.

(2) On a decreasing payroll with 100 separations and no hirings during a certain period, there has been no turnover, but if separations are used the result will be a turnover of 100.

[1] "Methods of Computing Labor Turnover," by Paul H. Douglas—Bulletin of the Taylor Society, August, 1919.

[2] *Personnel Management*, by Scott and Clothier, p. 561.

In favor of separations:

(1) Most separations are temporary and the breaking in of the new men represents a real cost to the employer.

(2) All separations mean a cost to the man and the public—the loss of income to the man and the loss of social income to the public—if the usual period of job-hunting follows.

(3) The causes of separations are not independent, but interdependent, and therefore all separations should show in the turnover figures if true answers to the industrial problems are sought.

In favor of payroll figures:

(1) Payroll figures always contain the whole labor force and the force-report figures fluctuate from 100 per cent to 50 per cent or lower. This fluctuation has no real relation to labor turnover. Hence, the percentage computed with such a fluctuating base is unreliable.

(2) Men often leave without notice and are not reported for several days, and the payroll figures in this case are the correct basis because these men should be included in the denominator of the turnover figure of the period which represents them. They are, however, dropped on the force-report figures.

(3) Payroll figures are easier to obtain as they come from one source, while attendance or force-report figures come from a large number of sources.

(4) Labor fluctuation, absenteeism, and tardiness probably will be studied in the near future. Payroll figures are the logical base to use in computing indices for these figures, and the use of the payroll figures as the base for labor turnover will save considerable clerical labor.

(5) The force report confuses absenteeism with labor turnover. This is a separate factor which is not confused with labor turnover if the payroll figures are used.

(6) The mean number of men on the payroll is a better measure of the risk of change than is the mean of the number of men on the force report. The risk of change varies with the number of men employed and the length of time employed.

(7) The payroll figures are simple and familiar to all. Force-report figures are not so generally used nor so familiar.

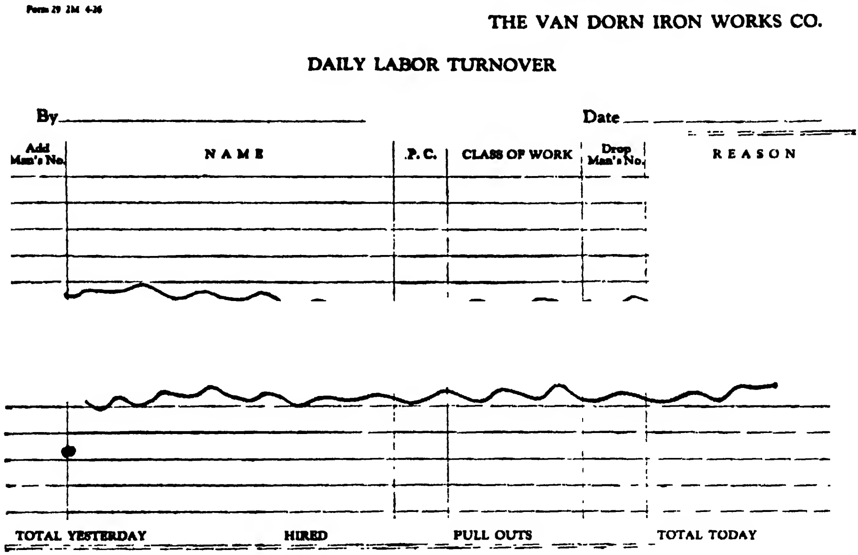
In favor of the force report:

(1) The payroll figures often contain large numbers of dead wood—men who have quit but have never called for their pay, men who have left without notice and are not paid at the time the turnover is computed, and so forth, and the force-report figures are cleared of all such names.

**The Significance of Labor Turnover.** Labor turnover is a measure of the stability of the organization. As such it gives some indication of the efficiency of the management, particularly when it is due to wages or working conditions over which the management has a large measure of control. A maximum quantity of work of the best quality cannot be obtained when the employees are irritated by improper supervision, when the air in a shop is fouled by noxious gases given off by the manufacturing processes, when wages are unfair as judged by current rates or when other conditions relating to wages or working

conditions are improper. A study of labor turnover in shops where it is unduly high may indicate conditions which warrant the attention of the management.

From considerations of its costs alone, labor turnover is worthy of the attention of the management. A number of students of personnel problems have made studies of the cost of labor turnover in American industries. Their estimates range from $5 per employee for unskilled labor to $3,000 per employee in the case of valuable executives. Esti-


THE VAN DORN IRON WORKS CO.

DAILY LABOR TURNOVER

By ______ Date ______

| Add Man's No. | NAME | P.C. | CLASS OF WORK | Drop Man's No. | REASON |
|---|---|---|---|---|---|
| | | | | | |

TOTAL YESTERDAY ______ HIRED ______ PULL OUTS ______ TOTAL TODAY ______

*Courtesy -The Van Dorn Iro*

FIG. 118

A Daily Turnover Record

mates of the average cost of labor turnover range from $40 to $250 per employee. It is not unusual to find a labor turnover of 100 per cent per annum or greater in the average plant operating under conventional management. If a conservative estimate of the cost of turnover is taken, say $50 per employee, such a plant employing an average working force of 1,000 employees would be losing approximately $50,000 per year. It is not possible or even desirable to reduce labor turnover to zero. Nevertheless, it is evident that considerable expenditures for personnel work can be made for the purpose of reducing labor turnover alone.

**Kinds of Labor Turnover.** Two kinds of labor turnover can be distinguished—natural and unnatural. Natural turnover is that which results from causes not due to any fault of the organization. It includes such causes as marriage, assumption of civic duties, greater business opportunities, promotion, seasonal and cyclical influences which can only partly be controlled. Unnatural turnover is that which results from causes which can be traced to poor management. It includes such causes as poor supervision, poor hours of work, unsatisfactory wages, improper training, and similar causes. In the average plant, natural turnover usually is a small percentage of the total turnover of the plant.

**Causes of Labor Turnover.** The scope of this book is such that any extended discussion of the causes of labor turnover is not possible. Therefore, we shall content ourselves with listing a few of the more important causes. They are:

(1) Nationality.
(2) Housing conditions.
(3) Sex.
(4) Training.
(5) Mentality.
(6) Marital status and dependents.
(7) Length of service.
(8) Wages and earnings.
(9) Conditions of work.
(10) Hours of work.
(11) Faulty supervision.
(12) Personal characteristics.
(13) Adaptability.
(14) Lay-offs, transfers, and promotions.
(15) Death, retirement, etc.

**Analyzing Labor Turnover.** A complete record of labor turnover for the plant should be kept in such a manner that it is possible to analyze the causes of labor turnover by departments. In some plants, a record of the turnover by departments is kept, but the causes of the turnover are not separated. While this may indicate those departments in which personnel conditions are poor, it is inadequate in that it gives no indication of the proper remedy. The detail in which the causes of turnover should be recorded probably will vary with each plant. Fig. 119 shows a labor-turnover record.

From the labor-turnover record, a report should be drawn off monthly showing the per cent of turnover in each department and the per cent due to each important cause.

**Obtaining the Turnover Data.** Unless there is some organized routine, it may be difficult to get complete turnover data. In some plants the employee may quit, get his money, and leave the plant before the per-

## Labor Turnover Analysis

________________________ Division:

Our records indicate the standing of your division in man power to be as follows for the month of______________:

| DEPARTMENTS | PUT ON | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | New | | | Re-em. | | | Trans. in | | | | | |
| | Experienced | Learners | Laborers | Experienced | Learners | Laborers | Physical reasons | Learners | Betterment | Promoted | Failed | Dept fluctuation |
| TOTAL | | | | | | | | | | | | |

| DEPARTMENTS | PAID OFF | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | Trans. out | | | | | | | | | | |
| | Wages | Heavy, wet, etc. | Ill health | Dissatisfied | Going to school | Leaving city | Going into business | Resigned | Limit of absence | Housing—Home cond. | Another position | Indifference | Incompetent | Unreliable | Trouble maker | Insubordinate | Misconduct | Trans. to field | Decrease force | Physical reasons | Leave of absence | Temp. employed | Learners | Betterment | Physical reasons | Promoted | Lacked ability | Dept. fluctuation | Marriage | Sickness | Death | Entrances | Exits |
| TOTAL | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

On payroll first of month________ On payroll last of month________ Per Cent Turnover________ Per Cent Unavoidable________

Printed in U.S.A.

*Courtesy—National Cash Register Co.*

FIG. 119

A LABOR TURNOVER SUMMARY

THE NASH MOTORS CO.
Milwaukee Division

## EMPLOYMENT RELEASE NOTICE

Form No. 44 5M Sets 10-26

| WORKMAN'S NAME | | | CLOCK NO. |
|---|---|---|---|
| WILL LEAVE / HAS LEFT OUR EMPLOY ON | DATE | HOUR | WORKED IN DEPT |
| OCCUPATION | SIGNED__________ Foreman | | |

Insert Carbon Only To This Line

| | OK. TO RE EMPLOY | | RATING | | |
|---|---|---|---|---|---|
| REASONS OR REMARKS | Yes | No. | Skill | Prod. | Cond. |

SIGNED __________________ Employment Dept.

PAYMASTER—Do not pay off Workman until Tool Stores Copy of this Notice is received

| FINAL PAYMENT MADE | |
|---|---|
| DATE | SIGNED BY PAYMASTER |

Send this copy to Employment Dept. for OK. then to Paymaster's Office.

*Courtesy—The Nash Motors Co.*

FIG. 120

A TERMINATION NOTICE

sonnel department is aware of it. Some means should be taken to compel each employee who quits to pass through the employment office. One way is to require that no employee can be paid off finally until he has received a release slip from the personnel department. The employee comes to the employment office with a termination notice made out by his foreman. The cause of the separation is stated on the notice by the foreman. The employment manager then has an opportunity to quiz the employee and to get his version of why he is quitting. In many cases a disagreement between the man and his foreman can be adjusted or he can be transferred to another department, thus saving part of the cost of turnover. If the employee cannot be retained, a release slip is made out in duplicate. The original is taken by the man to the cashier. It states the man's name and number, his reasons for quitting, whether he has turned in all company property for which he is responsible, and any other necessary information. It is forwarded by the cashier to the payroll department and is the authority for removing the man's name from the payroll. The duplicate is retained by the employment office and is the basis for the entries in the labor-turnover record. Much of the information recorded in the turnover record, such as nationality, sex, dependents, education, etc., can be taken directly from the employee's history card.

**The Labor Audit.** The labor audit is intended to give a thorough check on the soundness of the personnel methods in use in the plant. It is a searching study of the whole personnel problem with a view to developing a broad, fundamental perspective in its solution. Tead and Metcalf define the labor audit as "a reasonable, exhaustive, and systematic statement and analysis of the facts and forces in an industrial organization which affect the relations between employees and the management, and between employees and their work; followed by recommendations as to ways of making the organization more socially and humanly solvent."[1] This definition suggests the consideration of many problems which are not strictly within the field of management. In so far as the social problems of industry are accepted in current management practice as management problems, the definition is substantially correct.

The labor audit, if properly carried out, should serve a number of functions and a variety of purposes. If the technique has been properly worked out, it should provide a standard method for the diagnosis of an organization's labor relations. Such a standard is desirable for the reason that conditions in industry are constantly changing, and a periodic check of the effects of such changes on labor relations is necessary. Where a personnel system already is in operation, the labor audit

[1] *Personnel Administration*, by Tead and Metcalf, p. 289.

gives a desirable check on the effectiveness of the personnel organization. In this connection, the report tends to stimulate action and to furnish the personnel manager with basic information with which to guide such action. It assists him in formulating a long-range personnel program, based on policies which are fundamentally sound.

One of the fundamental functions of the labor audit is to educate the organization with regard to what should be done, as well as to indicate the efficiency with which present methods are operating. In many cases it will be discovered that important personnel functions are largely undeveloped, for the reason that the management has not realized that they are necessary. The labor audit should point out such needs and sell the management on the advisability of their development. The audit has another educational phase in that the report may be used to familiarize new executives with the company's labor policies and methods.

Tead and Metcalf state that there are at least four essential prerequisites to a successful labor audit. These are:

(1) A readiness on the part of the management, and preferably the workers also, to put all relevant facts and records at the disposal of the investigator.
(2) A properly qualified investigator.
(3) A method of conducting the audit and reaching all sources of information.
(4) A standard, exhaustive, and logically ordered check list of items.[1]

The labor-audit check list is a standardized list of factors affecting personnel work and labor relations which should be considered in making the audit. A discussion of the technique of making a labor audit is beyond the scope of this book. Such discussions can be found in texts on personnel management.[1]

[1] A detailed discussion is given in *Personnel Administration*, by Tead and Metcalf, Chapters XX and XXI.

# CHAPTER XXVIII

## OFFICE MANAGEMENT

**The Development of the Field.** Office management is one of the most recent phases of management to be recognized as a distinct field in itself. It is probably true that in a great majority of concerns today the office function is treated as a necessary evil, and the least possible time and thought is spent on it. Yet clerical hire is one of the major items in the nation's bill for wages and salaries. It is generally recognized that in the average concern there is a great amount of inefficiency in the conduct of office work. Despite this fact, it is only within the last fifteen or twenty years that any great amount of thought has been given to the development of this field. Even today there are only a very few consultants of ability operating in it. To a large extent the technique of office management is still to be developed.

One explanation of this condition is the intangible nature of the work which must be brought under control. In general, the work is such that it is difficult to establish objective measures of it. Without such objective measures it is difficult to compare the productivity of clerical workers or of clerical methods. It is only within comparatively recent years that anything approaching a scientific study of the problem has been made.

Another factor which probably has retarded the development of the field is the all-pervasive character of clerical work. There is hardly a phase of manufacturing which does not require some clerical work. An entirely clerical routine may lead through a number of departments, which are units in different organizations within the company. Usually, it is beyond the power of any one department head to study the routine for the purpose of eliminating inefficiencies which may have crept in over a period of years. In the first place, probably he cannot take the necessary time from his operating duties. In the second place, probably he would be met with the opposition, and perhaps jealousy, of the other department heads, who would resent what they would be likely to consider as his unwarranted interference with their functions. To develop and standardize office practice properly, the work should be placed under the supervision of an executive who has had some considerable training in the field and who can devote the major portion of his time to it. But the fact that clerical inefficiency usually is not apparent, and the pervasive character of clerical work, have prevented

the appearance of such a specialized executive until recent years. To-day such executives are to be found in a great many of the larger and more progressive industrial organizations.

Probably the detailed nature of office management can be given as a third reason why the field has not developed more rapidly. To a great extent it is concerned with the picking up and straightening out of loose ends in management routines. To most executives, the individual problems seem too insignificant to be worthy of their major thought. Undoubtedly, this is a reason why more executives having an analytical type of mind have not turned their attention to it. Certainly it is a reason why office-management problems have received too little attention in the average organization. Yet these same detail problems, if improperly handled, can cause large losses, due to the fact that serious interferences to the whole routine of management will result.

**The Office Manager.** In an increasing number of concerns, the function of office management is being recognized. In these concerns, an executive, the office manager, usually is appointed to administer it. His duties are to act as a coordinator between departments in the development of office routine, to develop and standardize office practice throughout the organization, supervise the training of office workers, and direct the activities of such clerical departments as may be assigned to his supervision. The departments which usually are placed in the office manager's organization are the messenger service, filing departments, stenographic service, telephone service, and various other office service departments.

In too many instances, the office manager is merely a good chief clerk, to whom the title has been appended. The unsoundness of such a policy is apparent with a moment's thought. His job requires something more than mere clerical skill and accuracy. It requires more than ordinary analytical and investigative ability because of the intangible nature of the clerical product. It requires some experience with the technique of developing office practice because already some such technique has been developed in this field which is peculiar to it. While it cannot be said that at the present time office management is a profession, the trend is distinctly in that direction. The office manager should have tact, personality, and sales ability because his work may lead him to an investigation of clerical activities which are directly under the supervision of other executives. Unless he has these attributes, it is unlikely that he will be able to bring about those changes which he feels are necessary. While this is not a complete inventory of the office manager's equipment, it is sufficient to make clear why

it may be most unsatisfactory to promote a high-grade clerk to the rank of office manager, and expect developments.

It is difficult to locate the office manager in the organization accurately, because of the newness of the position. When the secretary of the company is actually an operating executive, a logical position for the office manager is under the secretary's supervision. Such a position only involves a natural extension of the secretary's function. Under such conditions, the office manager's organization might be similar to that shown in Fig. 121.

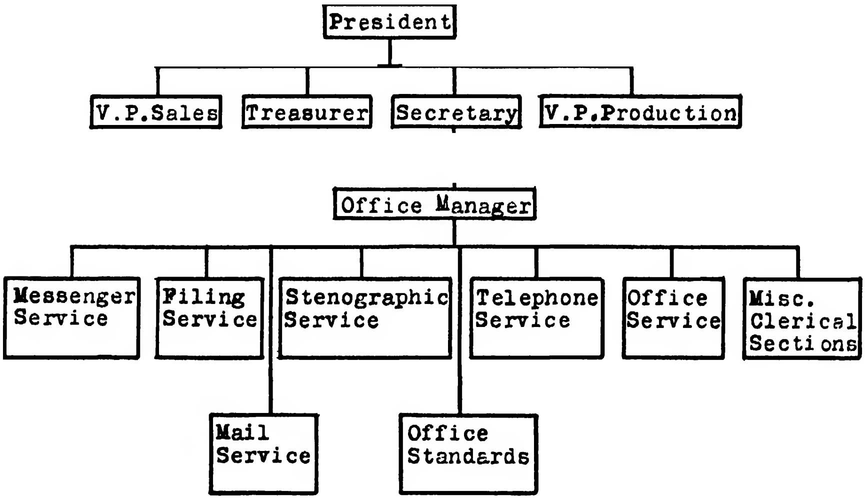



FIG. 121
THE OFFICE MANAGER'S ORGANIZATION

In some concerns, the secretary is merely a large stockholder whose actual participation in the operation of the company is relatively slight. Under such conditions, the above organization would not be satisfactory. Quite often the office manager is under the supervision of the treasurer or the comptroller, because of the large amount of clerical work involved in the performance of the financial and accounting functions.

The work of some of the office manager's department will be considered in order to make the scope of his function more clear.

**Messenger Service.** In a large organization a number of messengers may be employed in distributing mail, carrying special communications between various units of the organization, acting as guides for visitors, and in numerous other ways. The efficiency of the organization depends to a large extent on the smoothness and efficiency of intercom-

munication within the organization. In this respect alone, the messenger service is an important factor.

The usual sources of supply for messengers are casual applications, high schools, superannuated employees, and college apprentices. Casual applicants are only fairly satisfactory. A great many boys who apply for messenger work have left school because of laziness or because they are not mentally capable of advancing farther in school. They may be decidedly irresponsible. On the other hand, applications often are received from boys who are bright and industrious, who have been forced to leave school for financial or other reasons. For some types of messenger work, it may be possible to employ high-school students on a part-time basis. Where this can be done, it is possible to get a high grade of messenger boy. Some concerns employ superannuated employees as messengers. These employees have outlived their usefulness on their regular jobs. Yet, the company does not wish to discharge them, because of their good records, length of service, or for other reasons. However, they are not desirable for messenger work. In their case, messenger work may mean demotion to one of the lowest positions in the organization and loss of status in the eyes of their fellow employees. They do not bring any great enthusiasm or energy to their job. Because of their age, they tend to slow up the whole messenger service. If handled properly, the college apprentice can be used in the messenger service satisfactorily. Many concerns which wish to develop college graduates in their organization insist that they start in one of two places, depending on the line of promotion in which they are interested, either in the shop apprentice school or in the messenger service. The latter organization offers a particularly good starting-point for training in office functions, for the reasons that the apprentice becomes familiar with all of the units of the organization. He meets and comes to the attention of the executives in the various departments. In a general way he becomes familiar with the work being carried on by the various departments. Furthermore, if the apprentice has the stamina to swallow his pride and stay with the job until he is promoted from it, he has passed a good test of his ability, farsightedness, and ability to stick with a job. The nature of the messenger problem will determine which of these sources of supply shall be used. It may be necessary to use all of them to some extent.

It is a requirement of the messenger service that it be so organized that the executive can at all times get prompt and satisfactory service. A necessary step in the development of the messenger organization is the grading of messengers according to their experience and ability. They may be graded as "A," "B," and "C" messengers. The "A" messengers handle the messenger work of the executives. The "B"

and "C" messengers handle the routine work. Promotion within the messenger service obviously is from the lower grades to the "A" grade. As the messenger is promoted in grade, he should receive a substantial promotion in his wage rate. "A" messengers should be graduated into the regular clerical service if they have the necessary education and ability. Unless some such grading and promotion scheme is worked out, the incentive to apply themselves diligently to their work and to stay with the organization is lacking. Only those in the lowest level of intelligence and ambition will stay with the messenger service for any great length of time. In the case of college apprentices, the promotion through the various messenger grades must be made as quickly as possible. Otherwise the apprentice will lose interest in a type of work which is far beneath his intelligence, will become discouraged and quit.

Another problem is the control of messenger work. In the case of routine messenger work, it is customary to establish general delivery routes covering the whole organization or a number of departments. Mail, packages, routine interdepartmental communications, are left at various distributing points on the general route. Sub-routes, covering one or two departments, start from each delivery point. The messenger on a given sub-route takes the mail which has been left at his delivery point for the departments in his sub-route, and delivers it to the clerks in these departments, at their desks, after sorting it properly. In order to control the performance of the messengers, they are sometimes required to time-stamp cards at various points on their routes. These delivery times can be checked with a master schedule of deliveries.

**Mail Service.** Even the handling of mail presents a problem in the large organization. An organized mail service conserves the time of the executives and insures greater efficiency in the handling of correspondence. The problem can be divided into two principal phases, the handling of in-coming and out-going mail.

In-coming mail is first sorted into obvious groups such as the package group, first-class mail, second-class mail, special-delivery letters, registered letters, etc. The last two groups are handled at once because of their greater probable importance. After these, the first-class mail is opened and sorted. Advertising matter goes into one pile, letters with checks into another, etc. Letters and inclosures must be pinned together. Letters with checks should be forwarded to the cashier. The receipt of the check is recorded and the letter is forwarded to the proper executive for acknowledgment. Letters referring to previous correspondence should be forwarded to the files where it is attached. All in-coming mail should be stamped with the date and time of arrival

as a check against complaints from customers or others, the efficiency of the mail service, and our correspondents. Where there is considerable routine correspondence it may be advisable to number the letters of each correspondent with a number stamp. A record of these numbers by correspondents is kept. When the stenographer types the replies to the letters, she places the mail number, as well as the file number, on the letter. A copy of the number record is given to the chief file clerk. As the carbon copies of the letters come to the files, they are checked off on the record. By the end of the day, all letters should have been acknowledged. At the end of the day the file copy of the number record can be turned over to the person responsible for the handling of correspondence who can check into the causes of unanswered letters. In addition, the mail must be sorted according to the routes on which it is delivered. All first-class mail should be on the executives' desks before their arrival in the morning. After the first-class mail has been attended to, the second-class mail and the other groups are handled.

The out-going mail is collected by the regular messenger service. It is put through whatever routine may be necessary, sorted and bagged according to kind.

It is evident that in the large organization even such problems as the handling of mail, which are apparently simple matters, may require methods which cannot be worked out by the average clerk to the best advantage.

**The Files.** The filing of papers and records relating to the conduct of the business is an important problem of the office manager. Misfiling means the possible loss of valuable information, the waste of executives' valuable time, the loss of customers' good will, and irritating and costly delays in the routine of management.

The office manager must decide whether centralized or decentralized filing shall be the basis of his filing methods. Centralized filing has the advantage of greater uniformity throughout the organization. It is more probable that the best methods of filing, as worked out by the office manager to meet the particular needs of the company, will be carried out because of the better opportunity for supervision. It is easier to transfer file clerks between filing sections which in itself makes for better filing service. On the other hand, decentralized filing collects the information which is chiefly of value to a given department at the most convenient point. In the case of highly centralized or highly technical departments, such as the engineering department, this may be a distinct advantage.

In addition, the proper method or methods of filing must be

selected. It may be necessary to use different methods in connection with different kinds of work and in different units of the organization. The more common methods of filing are alphabetical, numerical, mnemonic, geographical, chronological, and subject. With the alphabetical method, the material is filed according to the letter in the subject which is most significant of its meaning. For instance, correspondence may be filed according to the first letter in the name of the firm or according to the first letter in the subject to which it refers. Often there are a number of choices as to the letter under which the material may be filed, with corresponding chances of misfiling. Accordingly, it may be necessary to cross-file by means of standard cross-filing forms, on which the name and subject of the material appear, placed in the various alphabetical filing pockets in which the file clerk might look for the material. For various reasons, this method of filing is relatively slow. Nevertheless, it is probably the most common method in use in industry.

The numerical method is a development from the alphabetical method which is designed to get greater speed and accuracy in filing. The basis of the method is the assignment of a definite filing account number to each name or subject under which material is to be filed. Base numbers are assigned to each letter of the alphabet. For instance, the base numbers for names or subjects beginning with B might range from 15 to 20. The base number for those beginning with Br, might be 18. The correspondence account number for Brown & Company might be 1856. Under this system, the clerks who open the in-coming mail, the stenographic section, and each file section should have a visible index of correspondence symbols. When a letter from Brown & Company is received in the mail department, the mail clerk writes their correspondence account number on the letter. When it is answered, the stenographer types the account number on the bottom of the reply. Because of the numerical sequence, greater speed and accuracy in filing is obtained. While the amount of cross-filing is reduced, it is not entirely eliminated.

The mnemonic method depends on the development of a system of symbols which will naturally classify the material according to its name or subject, and which will suggest the classification by the construction of the symbol. The word mnemonic means "memory aiding." A discussion of the construction of mnemonic symbols is given on page 268 in connection with the development of material symbols. This method is not readily adapted to the filing of correspondence.

The basis of the geographical method is the filing of correspondence according to the geographical location of its origin. This method

has been found convenient, in some instances, in connection with the filing of customer correspondence and customer and sales data in the sales department. Obviously, its possibilities are limited.

The most common example of the chronological file is the "tickler" file. The filing subdivisions are arranged according to time, as the days of the week and the months of the year. An executive wishes to review certain material on June 26th. He places the material in his outgoing-mail basket with a memorandum to that effect. When the material is received in filing section, it is placed in the "tickler" file in back of the guide for June 26th. Each day the material in back of the guide for that day is taken out and forwarded to the proper executives. The guide is placed at the back of the file. When June 26th arrives, the executive will receive his material automatically. The chance that he will forget the matter is reduced to a minimum.

In subject-filing, as the name indicates, the material is filed according to its subject matter. The subjects may be arranged in the files alphabetically or according to some mnemonic system. This type of filing is advantageous when the general subject of the correspondence is important rather than the writer. An example of this is the engineering departments files in which correspondence and data relating to some particular project of engineering design or development are filed according to the name of the project.

Even the selection of the type of files offers opportunity for the exercise of judgment. There are vertical files in steel or wood commonly used for filing correspondence and data of various kinds, card files for filing cards of various kinds and sizes, to which data have been transferred. Tub desks, used in many cost departments for the filing of cost cards, are a modern development of the card file. There are a large number of types and styles of book type files. The more common are the bound book, the loose-leaf book, and the visible index.

The files should be directly under the supervision of a chief file clerk, who checks and supervises the work of filing.

**The Stenographic Service.** In the well-organized stenographic service it is often found desirable to grade the employees on the basis of their ability. In general there are three grades—typists, stenographers, and secretaries. The typist can only operate a typewriter. She is available for copying, filling out records, etc. The stenographer is able to take dictation as well as operate a typewriter. In addition, the secretary is able to relieve the executive of many of the details of his job by reason of her greater experience, ability, and initiative. Very often the job of secretary leads to promotion into the executive ranks, particularly in the case of competent male secretaries.

In the stenographic section also there is the problem of the centralized *versus* the decentralized section. Whenever possible, it is better practice to centralize the stenographic section. It is then possible to make a more efficient disposition of the stenographic forces. When a girl finishes the work to which she is normally assigned, she can be given any other work which may have come into the stenographic room. She is not waiting until more work from a particular source is given to her. Because of the possibility of better supervision and more efficient disposition, the organization is given better stenographic service. The quality of the work is likely to be higher for the reason that the best standards of work can be determined and uniformly enforced. It is probable that more work will be obtained from the stenographers because the centralized section offers greater possibilities of measuring the production of each stenographer and typist, and of adjusting salaries in accordance with ability to produce.

In highly specialized departments, the decentralized section may have the advantage that the stenographers become more efficient through greater familiarity with the technical requirements of the work. Furthermore, in very large offices, covering a large amount of floor space, the centralized section may not be satisfactory because of the distances separating the different units of the organization.

**Office Service.** The work of office service is an excellent example of the type of work which seems relatively unimportant in itself and which is extremely important in relation to the smooth operation of the office organization.

The work may be divided into two phases—office standards and desk service. Space limitations make it impossible to give anything approaching a complete discussion of these phases for the reason that they include too many details. It must be sufficient to say that office standards include the standardization of office supplies, equipment, and practice. Without such standards we cannot hope to have economy of office operation. Desk service has to do with the replenishment of desk supplies and the control of office supplies. When the office worker runs out of paper, pencils, clips, or other supplies necessary to the work which he is doing, an interference to clerical production has occurred, inasmuch as the clerk must either borrow from a neighbor or leave his desk to get a new supply. Such losses of time, insignificant in themselves, are constantly occurring in the average clerical organization, and in the aggregate amount to considerable.

**Office Layout.** The proper arrangement of office workers and equipment is important to efficient clerical production as the arrangement of men and equipment is to production in the shop. The arrangement

and standardization of conditions under which clerical work is done is an important phase of the office manager's job. He must deal with such problems as the proper location of desks with regard to natural lighting, proper artificial lighting, the arrangement of desks and the location of desk phones, the location of offices, and similar problems.

Departments and clerical units should be so located that the various papers are handled smoothly and quickly, with the least possible moving. Noisy departments must be segregated. The offices of executives coming in contact with the public must be located near the public entrances. These and many other problems of office layout affect clerical production.

**The Selection of Office Equipment.** During a period which has not been much longer than the average business lifetime, there has been a remarkable development in office equipment. Today, there is a variety of equipment for performing a wide range of office operations, with varying degrees of automaticity, which formerly were performed entirely by hand. The modern office manager must be familiar with the possibilities of many styles and types of adding machines, computing devices, typewriters, book-keeping machines, tabulating machines, filing equipment, office furniture, and many other items too numerous to be listed. While the development of office machinery has increased clerical production, it has added to the complexity of the office manager's function. Probably it is a factor which has tended to specialize the work of office management.

**Standards of Performance.** A relatively new and increasingly important phase of the office manager's work is the development of standards of office performance. When such standards are developed for the majority of the work of any given clerical unit, the work can be planned and scheduled, operatives can be paid in proportion to their production, and various modifications of the practices which have given to the modern production organization its remarkable efficiency can be introduced. As yet, standards have been developed only for such routine clerical work which is handled in volume. Typing, filing, and duplicating are examples. The fact that some concerns are experimenting with time study and micro-motion study in connection with the development of office production standards is a significant indicator of the trend of office-management practice.

**The Growing Importance of Office Management.** Because clerical and administrative expense is such an important item, particularly in the larger concerns, it is probable that the function of office management will continue to grow in importance as its possibilities become more generally realized by operating executives.

The office problems which have been discussed briefly give only

a passing glimpse of the field of office management. They are intended only to bring out the point that while office management deals with details, individually of minor importance, their proper handling is vitally important to the smoothness with which the routine of management is operated.

## CHAPTER XXIX

## COST CONTROL

**The Functions of Cost Control.** Industrial cost accounting has to do with the collection or determination of the various items of direct and indirect expense incurred in manufacturing, the proper distribution of these to the various items of product, and the determination of the manner in which the expense items vary, to the end that the results of manufacturing activities may be gauged more intelligently and as a result may guide future activities to the best advantage. Industrial costs supply information which is essential to the proper financial control of the company's activities, and furnish a measure of the operating effectiveness of the organization.

If the cost system is to be of value in making intelligent executive decisions, it must be so organized and operated that cost reports are rendered promptly after the completion of given manufacturing activities. These activities may be related to a specific order or a manufacturing period, depending on the nature of the product and the conditions and methods of manufacturing. Currency of information is an important requirement for a good cost system. Furthermore, cost reports should be comparable not only with previous periods, but also with definite standards of performance. Otherwise, it is difficult to determine whether the reported costs of different items of product are reasonable. Costs should be reported in sufficient detail to enable the executive to determine the cause and the responsibility for variations from the standards or comparable reports for previous periods.

In a great many lines, accurate estimates of the cost of production by items of product are valuable aids in determining the probable financial requirements for coming periods, and in determining reasonable selling prices with regard to the trend of markets and the prices of competitors. While the cost department may not make such estimates in all cases, the cost system should be able to furnish information on which they can be based.

Often it is not sufficient to know that costs are higher than they should be and that the increases occurred in certain departments. The executive must know the cause of the increase if he is to prevent a recurrence of it. It is a function of cost control to furnish, through its detailed cost reports, adequate information regarding such causes.

Finally, it must be able to furnish any other statistical information

relating to expense and costs which may be necessary to the proper conduct of operations.

**The Advantages of Cost Control.** In many lines, the manufacturing processes are exceedingly complex. The mechanism for the control of operations is correspondingly complex in any except very small plants or those in which the manufacturing processes are few or simple. The items which enter into the costs of the different products are many and varied. Often it is difficult to determine their proper distribution over these products. Without a good cost system it may almost be impossible.

It is not unusual to find, in a plant that has been using poor cost methods, that, although the company has been making money, it has been doing so because certain products have returned more than an ordinary profit. Other products which apparently have been returning a profit, actually have been sold at a loss. The cost reports have presented an erroneous picture of the situation. With competition as keen as it is in industry, obviously this is a dangerous condition.

As a result of this keen competition, many concerns are finding it not only advisable, but necessary, to forecast accurately the results of their manufacturing activities, and to check the effectiveness of these activities as they progress. It is difficult to do this without the aid of a well-organized cost system.

It hardly seems necessary to justify a good cost system as an essential tool of management. Yet a great many concerns continue to use cost methods which are antiquated. In some instances it may be due to the fact that the head of the organization has developed the business from small beginnings. The business has outgrown the cost methods without this condition being realized. It may be that the chief executive prides himself on being a "practical" shop man, and views all "paper work" with the tolerant contempt that is common in such cases. Unless an expense can be shown to have a fairly direct connection with production, it is regarded as nonproductive and something to be avoided. In other instances, he may be progressive, but, having little or no knowledge of cost accounting, does not appreciate the advantages of a good cost system. Possibly he feels that costs are merely records of what has been done, expressed in terms of monetary rather than physical units, that they cannot give him appreciable aid in the management of the plant beyond that which is already given to him by his production records. Unfortunately, this criticism is true in too many cases because the cost systems have not been developed properly to meet the needs of the business.

**The Nature of Product Costs.** The finished product must bear those expenses which are incurred as a direct result of its manufacture, and

in addition, its proportionate share of those expenses which are necessary to the conduct of manufacturing operations, but which cannot be charged directly against a specific production order. The latter are usually termed burden, overhead, or indirect expenses. To illustrate, taxes are a part of the general cost of doing business. They are not caused by any particular lot of product which may be traveling through the works. Nevertheless, a proportionate charge for taxes must be included in the cost of the product if the company is to be properly reimbursed by the public for the expenses which have been incurred in rendering the service of producing the goods which it demands.

The total cost of the product usually is broken down into its elements, which correspond roughly to the general divisions of manufacturing activity. These elements are direct material, direct labor, and burden. The direct material charges include the costs of those materials which enter directly into the manufacture of the product and which can be charged to a specific production order. Similarly, the direct labor charges include the costs of all labor which is applied directly to the manufacture of the product and which can be charged to a specific production order. The burden is the proportionate share of the indirect expense of manufacturing to which reference has been made previously. The sum of the direct labor and direct material costs is called the prime cost of the product.

In most instances, the burden is further broken down to permit the collection and classification of indirect expenses according to the major divisions of the organization. Usually the general classifications of indirect expenses are factory expense, administrative expense, and selling expense. These classifications may be broken down further in as great detail as may be necessary.

It follows that the cost of an article is made up as follows:

| | |
|---|---|
| (Direct material) + (Direct labor) | = Prime cost. |
| (Prime cost) + (Factory expense) | = Factory cost. |
| (Factory cost) + (Administrative exp.) | = Cost to manufacture. |
| (Cost to manufacture) + (Selling exp.) | = Cost to sell or total cost. |
| (Cost to sell) + (Profit) | = Selling price. |

The "cost to sell" is the proper basis from which to determine what the selling price should be. However, the cost must be reasonable as determined by competitive and other business conditions. We cannot expect the public to reimburse the company for that portion of the expense of manufacturing and selling which is due to the inefficiency of management.

**Classes of Costs.** There are two types of costs, historical and prospective. Historical or collected costs show what has been the expense, direct and indirect, of manufacturing definite quantities of each kind

of product. They are collected by means of reports furnished to the cost department as the product passes through the various stages in its manufacture. These reports are of various kinds, depending on the nature of the expenditures that are being reported. The cost of the product is not known until manufacturing has been completed. Comparison with previous costs of the product may tell us whether the cost of a given quantity of product is reasonable, but this information is not available until it is too late to take any action to hold the cost within reasonable limits. However, it should indicate what should be done to prevent high costs in the future.

Prospective costs show, in advance of manufacturing, what the cost of the product should be. Obviously they cannot be determined on the basis of actually reported expenditures, but rather on cost standards based on past results or scientific analyses. They permit the anticipation of manufacturing expenditures, and the checking of these expenditures as manufacturing proceeds. They furnish a more satisfactory basis for comparison with collected costs, inasmuch as the costs of previous orders may have been collected under conditions which differ materially from present conditions. Prospective costs are more truly a standard of accomplishment.

Historical costs will be considered first. It should be remembered that the basic cost elements, which have been previously noted, are common to both historical and prospective costs, although the methods of determining their values differ greatly.

**Direct Material Charges.** Two types of material expenditures enter into the cost of the product—expenditures for direct and indirect materials. Direct materials are those which enter directly into the manufacture of the product and which can be identified definitely with the production of a specific quantity. Many materials may enter directly into the manufacture of the product, but it would be impossible or impractical to charge some of them directly to a specific production order number. The gas that is burned in a furnace for heat treating steel enters directly into the manufacture of the product. However, a number of pieces, which are being manufactured on different orders, may be heated in the furnace at the same time. Furthermore, a certain amount of gas must be burned in order to bring the furnace up to the correct temperature. For these and other reasons, it is impossible to charge the gas directly to the order number of the pieces that are heated. In a great many instances the direct materials become a part of the finished product, either in their original form or otherwise. A certain piece is to be manufactured from machine steel. The required number of feet of steel stock can be determined definitely, withdrawn from steel stores, and charged to the order number for

the piece. However, the above condition is not an exact criterion because sometimes materials may not become a part of the product and yet may be treated as direct materials. During the war, when cartridges were being manufactured in large quantities, one concern endeavored to charge the punches used in drawing the brass cartridge cases directly to the order on which they were used. In this case tools were being treated as direct materials. In general, it is desirable, in so far as it is practicable, to charge the material used in producing a given quantity of product to the order for that quantity. Similarly, if a given material can be classed as direct material, it is desirable to do so. However, it should not be carried to extremes that will result in unduly complicating the cost methods, making the increased expense of operating the cost department greater than any savings which can be made through a closer control of costs. The law of diminishing returns applies to refinements in management methods as well as to other forms of economic activity. Nevertheless, there is a real advantage in charging as much material directly to a specific order as is practicable, inasmuch as it aids in establishing a closer control over the use of materials.

Unfortunately, it is not possible to clarify the question of what is and what is not direct material by presenting a classification of materials, because such a classification is different in every plant. The difference might be due to differing production and accounting methods, or it might be due to differences in the products. Furthermore, what is finished product in one plant may be direct material in the next. The high-speed steel of the steel manufacturer is the raw material of the tool manufacturer.

The cost problems in plants in the same industry may be similar in their general aspects, but it is not probable that they will be exactly alike, due to individual differences in methods. Therefore one cannot expect to find a standard method for collecting direct material costs. In the majority of well-managed plants, a manufacturing order is issued when it is desired to manufacture a given quantity of a product. This order, which gives the production organization the authority to fabricate the quantity, usually is issued on the authority of a manufacturing program, a manufacturing requisition originating from the balance-of-stores books, or a specific sales order. Under the authority of the manufacturing order, various production orders and sub-orders may be issued authorizing the manufacture of the component parts which make up the product, and the operations which must be performed on these components. The exact method of authorizing the various production activities will depend on the nature of the production problems and the production organization and methods. If there

MODEL PART CHARGE SYMBOL

SHOP

QUANTITY ORDERED DATE SIGNED CARDS—CARD NO.

| DATE | QUANTITY | | TOOL COST | DIRECT LABOR | | | | BURDEN | | TOTAL COST | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | STARTED | FINISHED | | HOURS | DAY WORK | HOURS | PIECE WORK | HOURS | AMOUNT | WEEK | TO DATE |
| TOTAL | | | | | | | | | | | |

8133 7M 10-19

FIG. 122
A Cost Card—Front

| DATE | QUANTITY | | TOOL COST | DIRECT LABOR | | | | BURDEN | | TOTAL COST | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | STARTED | FINISHED | | HOURS | DAY WORK | HOURS | PIECE WORK | HOURS | AMOUNT | WEEK | TO DATE |
| CARRIED OVER | | | | | | | | | | | |
| TOTAL | | | | | | | | | | | |
| COST PER 100 | | | | | | | | | | | |
| LAST MOST PER 100 | | | | | | | | | | | |
| AVERAGE COST PER 100 | | | | | | | | | | | |

FIG. 123
A Cost Card—Back

is a planning department, it will write the necessary production papers and forward them to the shop in accordance with its production schedule. A copy of the manufacturing order, or what corresponds to it, is forwarded to the cost department and is its notice to make out a cost sheet for the order. Figs. 122 and 123 illustrate a cost card.

Among the production papers which must be made out are requisitions authorizing the withdrawal from stores of the material for the order. If there is no planning department, these requisitions usually are made out by the foreman of the department in which the work starts. The material name, symbol, and description, and the order

ARTICLE CHARGE

CARDS—CARD NO. SYMBOL

| WEEK ENDING | ISSUES FROM STORES | | | | DELIVERIES TO STORES | | | |
|---|---|---|---|---|---|---|---|---|
| | KIND | QUANTITY | PRICE | AMOUNT | DATE | QUANTITY | PRICE | AMOUNT |
| | | | | | | | | |
| TOTAL | | MATERIAL SUMMARY | COST CARD | | | | | |

FIG. 124
A MATERIAL SUMMARY COST CARD—FRONT

number to which it is to be charged, are entered on the requisition. Before the starting operation begins, the requisition is sent to the storeroom and the material is delivered to the department. The requisition is forwarded by the storeroom to the balance-of-stores department, where the withdrawal of the material is entered on the stores ledgers.[1] The requisition credits the stores account for the material with the value of the quantity that has been withdrawn, and charges the order number with a corresponding amount. In some cases the unit price of the material may be entered on the requisition from the stores ledger. In others, it may be entered in the cost department. The balance-of-stores department forwards the requisition to the cost

[1] See balance-of-store department, p. 249.

department. The total value of the materials withdrawn is then posted to the cost sheet for the order. As various other materials are withdrawn from stores for use in the manufacture of the order, their cost is collected similarly. Fig. 72 illustrates a material requisition.

In some cases the material costs may be collected separately from the other costs of processing the order, either as a matter of convenience or to gain better control of material charges. When the product is manufactured to order, the material cost is often collected on the bill of material for the order. In other cases, it is collected on a

TRANSFERS TO REPAIR LOTS

FIG. 125
A Material Summary Cost Card—Back

material-cost card similar to that shown in Figs. 124 and 125. On its completion, the total cost of the material issued for the order is transferred to the cost card.

Very often the total quantity to be manufactured is broken up into relatively small lots for convenience in controlling production. This would be particularly true when a standard product is being manufactured in large quantities and a considerable length of time is required for manufacturing. In such cases there would be deliveries of finished product to stores before the completion of the total quantity in the order. Just as a stores requisition is issued when material is withdrawn from stores, a stores credit is made out when material is returned to stores. In the case of finished product which is being put into stores, a special form of stores credit, that can be easily dis-

tinguished, is used. An example of one is shown in Fig. 126. Its function is to credit the order with the cost of the quantity delivered, and charge finished stores with a corresponding amount. These credit slips go to stores with the quantity delivered, are forwarded by stores to the balance-of-stores department, where they are posted to the stores ledgers, and then are forwarded to the cost department. Here they are posted to the material cost card.

Inasmuch as the deliveries have been made before the completion of the order, they must be charged to stores at the unit price of the last order. The unit quantity on which costs are based may be any number which is convenient for cost and production control. It is unlikely that the cost of the present order will be exactly the same as that of the last

| WORKED MATERIALS SYMBOL | WORKED MATERIALS CREDIT 2098 1M 3 17 | CREDIT TO | |
|---|---|---|---|
| PLEASE CREDIT THE FOLLOWING WORKED MATERIALS | | QUANTITY | KIND OF UNIT |
| RETURNED FROM | | | |

ONLY ONE ITEM ON EACH CREDIT

| WRITTEN | APPROVED BY | DATE APPROVED | UNIT PRICE | TOTAL VALUE |
|---|---|---|---|---|
| | NOTICE TO WRITER—USE ONLY SPACE BETWEEN HEAVY LINES | | | |

| INSPECTED DATE | INSPECTED BY | LOCATION | RECEIVED IN STORES DATE | RECEIVED IN STORES BY | ADDED TO TAG BY | ADDED TO BAL SHEET BY | EXTENDED BY | CHECKED BY |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

| ALL EXCESS WORKED MATERIALS MUST BE RETURNED TO THE STOREROOM ACCOMPANIED BY THIS FORM | COST DIV | COST DIV |
|---|---|---|

FIG. 126
A Stores Credit Slip

order. Therefore there will be some discrepancy which must be adjusted when the order is finally closed out.

Indirect material includes that material which is necessary to the manufacture of the product, but which cannot be charged directly to it. It includes such materials as oil, waste, belt lacings, etc. It is part of the indirect expense of manufacturing and is distributed over the product by methods which will be discussed later.

**Direct Labor.** As in the case of material, it is possible to distinguish between direct and indirect labor charges. Direct labor includes all labor that is applied directly to the product and that can be charged directly to a specific production order number. A mechanic is assigned the job of boring, turning, and facing a gear blank, on a lathe. The time when he starts and finishes the job can be noted, and the elapsed time charged directly to the order number on which the blank is being

made. However, it does not follow that because the labor is applied directly to the product, it can always be classed as direct labor. Using the heat-treating illustration again, when the teeth have been cut in the blank, the gear will be sent to the hardening room to be hardened. Probably it will be heated in a hardening furnace with a number of other pieces. It is impracticable to charge the time of the heat treater, that is used in hardening the gear, directly to its order number. Yet this labor is applied directly to the product. As in the case of materials, there is the difficulty that no universal classification of direct and indirect labor can be made. The classification will be somewhat different in each plant, depending on the conditions and methods of manufacturing. The only rule that can be laid down is that, whenever possible and practicable, labor should be charged directly against the product.

In order to collect direct labor costs, the cost department must receive accurate reports of all labor time that can be charged directly against a given order. A common practice that is followed in a great many plants is to issue to the workman a ticket when he starts a new job. This ticket is variously called an operation ticket, time ticket, or work ticket, depending on the nomenclature in use in the particular plant. An example of such a ticket is shown in Fig. 40. The employee's name and number, the order number to which his time is to be charged, the kind and quantity of product, the operation number, and any other information necessary to the proper control of production and costs is entered on the ticket. The functions of the operation ticket are, to furnish:

(1) An accurate report of all labor charged directly against the order.
(2) Information to be used in checking the employee's efficiency.
(3) Information for payroll purposes.
(4) Information for production control.

When the operation ticket is issued by the shop clerk to the workman, the starting time is stamped on it. When the job has been completed, the workman returns the ticket to the shop office and the shop clerk stamps it with the finishing time. The difference between the starting and finishing times is the time which has been taken to complete the job, including any time which the workman has spent in setting up and adjusting his machine, getting his tools, and changing his operation tickets. The operation ticket is forwarded from the shop office to the factory office, where the above extension is made. The time actually taken may be compared with the standard time for the job and the employee's efficiency computed. If some system of wage payment in proportion to production is in operation, the employee's bonus earnings, corresponding to his efficiency, may be determined and entered on the operation ticket. In a great many plants in which a piece-rate system

is used, it is only necessary to compute the piece-rate earnings and post them to the ticket.

In large plants, a great many operation tickets are forwarded to the factory office periodically during the course of the day. These tickets are extended as previously described, and sorted by employees' names. The total earnings of each employee for the day are posted to the payroll. These earnings may consist of daywork, piecework, or bonus earnings.

It is common practice to require the employees to record their entrance and exit time on time-recording clocks, placed at the factory or department entrance. When the employees are on a straight daywork basis, this clock time is usually the basis of wage payment.

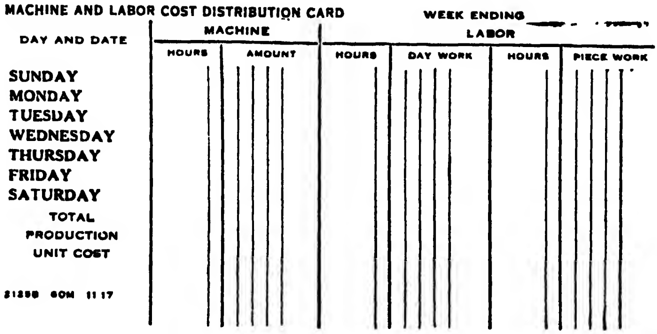



FIG. 127
A DISTRIBUTION CARD

When piecework, or some other form of wage payment in proportion to production is used, it becomes necessary to use some device similar to the operation ticket illustrated in Fig. 40 to report piecework or bonus earnings. In some cases time-recording clocks are not used, and the operation tickets are the sole record of the employee's time and earnings. The total time recorded on the employee's tickets for a given day should equal the standard time for the work period, unless the employee has been absent or tardy.

The postings to the payroll constitute a credit to the employees. To keep the books in balance, there must be a corresponding charge against the orders on which their labor has been expended. To get this charge, the operation tickets are forwarded to the cost department, where they are sorted according to the charge symbols on them. The total labor charge against each symbol is posted to the cost card for that charge symbol. In some cases this "break-down" of the operation tickets against the various charge symbols may be done in the

factory office rather than in the cost department, as a part of the work of compiling reports for the production organization. Where this practice is followed, the labor charges for the week against each order may be summarized on a distribution card for that order similar to Fig. 127. These cards are forwarded to the cost department at the end of the week. The postings to the cost cards are made from the distribution cards rather than from the operation tickets. Reports of the labor distribution may be entered from the distribution cards on summary cards for the information of the production organization, if desirable. Fig. 128 shows a summary card of this kind.

—SHOP FOR WEEK ENDING—

SUMMARY OF PAYROLL DISTRIBUTION AND MACHINE BURDEN EARNED

| INDIRECT LABOR | | | SUMMARY | | |
|---|---|---|---|---|---|
| CHARGE | HOURS | AMOUNT | | HOURS | AMOUNT |
| | | | IND LABOR | | |
| | | | DIR LABOR | | |
| | | | TOTAL LABOR | | |
| | | | MACH AVAIL. | | |
| | | | BURDEN EARNED | | |
| | | | BAL. UNEARNED | | |
| | | | RATIO IND TO DIR. LABOR | | |
| | | | DIR LAB PER MACH HR RUN. | | |
| | | | IND LAB PER MACH HR. RUN | | |
| TOTAL | | | SIGNED | | |

COPY NO. 1—FOR PROD. SUPT. 2006A 2M 10-17

FIG. 128
A DISTRIBUTION SUMMARY CARD

The direct material and direct labor charges now have been collected on the cost card for each order. The amount of indirect expense to be charged against each order must be determined before the costs are complete.

**Indirect Expense.** Indirect expense includes all items of expense that are necessary to the conduct of manufacturing operations, but cannot be charged against any particular production order. It includes many items of an intangible nature, such as charges for depreciation of buildings and equipment, that at best cannot be charged off against the orders passing through the plant with any high degree of accuracy. For this reason, undue refinement of methods for collecting and distributing indirect expense is to be avoided.

Indirect expense can be considered to be made up of indirect material charges, indirect labor charges, miscellaneous controllable expense, and fixed charges. To some extent it is within the power of the organization to control the first three classes of expense items. They tend to fluctuate, in some degree. with fluctuations in the volume of

production. However, they increase or decrease in a lesser degree than corresponding fluctuations in production. Fixed charges fluctuate very much less with fluctuations in production. Whether we manufacture one piece or one hundred thousand, it will be necessary to pay about the same taxes on land, buildings, and equipment. This classification is intended to lay emphasis on the fact that indirect expense is not a necessary evil that is beyond the control of the organization. On the contrary, the fluctuations in controllable expense with fluctuations in production can be predetermined, within reasonable limits, in a great many cases. The organization should be held responsible for holding such expense within these limits.

Indirect materials include those materials which are necessary to production, but which cannot be charged against any specific production order. They include such items as belting, oil, waste, and similar items. The life of the belt which drives a machine is ordinarily much longer than the time required to process a lot of product. Although the belt is absolutely necessary to production, it is impracticable to charge off the life of the belt against the orders as they pass through the machine. To a large extent, the magnitude of the total indirect material charges is dependent on the economy with which the shop is operated.

Indirect labor includes all labor that is necessary to production, but cannot be charged against a particular order number. It includes the labor of foremen, shop clerks, truckers, machine adjusters, and similar labor. Such labor should be considered to be productive, but indirectly applied to the product. The term, "nonproductive labor" is misleading. If it is really nonproductive, it ought not to be on the payroll. In some plants, it is the practice to limit the indirect labor to a fixed per cent of the direct labor. Unless this policy is handled intelligently, it may do more harm than good. As long as the application of additional indirect labor produces savings, by facilitating production, that are greater than the cost of such labor, it is to be desired rather than abhorred. The use of a fixed percentage to control indirect labor, therefore, may prevent economies by preventing necessary expenditures for such labor. As in the case of indirect materials, the organization has some opportunity to control the expenditures for indirect labor. Therefore its effect on the cost of the product is dependent on the economy with which the shop is operated and the wisdom with which such labor is applied.

As stated previously, the various items of indirect materials, indirect labor, miscellaneous controllable and fixed expense, usually are collected and grouped according to the major divisions of the organizations. These in turn may be broken down into as many expense

accounts as may be necessary for the proper control of expense. For instance, under the head of factory expense, we shall undoubtedly have an account for factory office expense, and possibly under this sub-accounts for clerks' salaries, executives' salaries, office supplies, and similar items. The nature of the items which make up the indirect expense of manufacturing can be understood better after an examination of the following list. Although it is sufficiently comprehensive for illustrative purposes, it is by no means complete.

FACTORY EXPENSE

Major executives' salaries.
Minor executives' salaries.
Clerks' salaries.
Office supplies.
Foremen.
Shop clerks.
Inspectors.
Truckers.
Maintenance expense.
Janitor service.
Power expense.
Tool expense.
Engineering expense.
Oil.
Waste.
Soda water.
Belting.
Idle time.
Scrap.
Heat and light.
Depreciation.
Insurance.
Taxes.
Rent.
Interest.[1]

ADMINISTRATIVE EXPENSE

Executives' salaries.
Clerks' salaries.
Office supplies.
Other administrative office expense.
Legal expenses.
Maintenance—office equipment and building.
Depreciation—office equipment and building.
Janitor service.
Heat and light.
Insurance.
Taxes.
Rent.
Interest.[1]

SELLING EXPENSE

Sales executives' salaries.
Clerks' salaries.
Office supplies.
Office expense.
  Telephone.
  Telegraph.
  Postage.
Sales research expense.
Sales promotion expense.
Advertising expense.
Salesmen's salaries.
Salesmen's commissions.
Traveling expenses.
Maintenance—office equipment and buildings.
Depreciation—office equipment and buildings.
Janitor service.
Heat and light.
Insurance.
Taxes.
Rent.
Interest.[1]

[1] Many accountants do not favor including interest on invested capital in the cost of production.

The original sources from which information regarding indirect expenses are obtained are material requisitions, operation tickets, vouchers or purely book transactions. In the case of the majority of factory expense items, these papers pass through various channels, depending on the particular cost procedure, to the cost department where they are collected under various expense accounts.

Routine expense expenditures usually are charged to standing orders. Standing orders are orders, permanently open, to which all expenditures of a specified nature are charged. It is not necessary to open a separate account for each expenditure. Periodically, the total expense charged against each standing order is closed out and charged to the proper expense-controlling account. To illustrate, it would not be worth while to write up a cost card each time an order is issued to repair a machine. In most cases the knowledge that a few dollars had been spent in repairing a particular machine would not greatly assist the management of the plant. However, it is decidedly helpful to know the total amount of such expense in each department during a given period, and it may be necessary for accounting purposes. Suppose that in a system of mnemonic expense symbols the symbol D4MM is the charge symbol for machine repairs in department No. 4 of the machine shop. When a machine breaks down, an expense order is written, using the above charge symbol to which all material and labor expended in repairing the machine is charged. D3MM would be the corresponding charge for department No. 3. If the expense accounts are closed out monthly, the total amount charged to this symbol is the total expense for machine repairs in this department for the month. The total of the DMM accounts gives the total machine repair expense in the machine shop.

When it is necessary to pay such expenses as interest, taxes, insurance, rent, and similar items, a voucher authorizing the issuing of a check usually is originated. Such vouchers are the bases of the charges for these items to the proper expense accounts.

There are a number of indirect expense charges, such as those for depreciation, which are not made on the authority of operation tickets, requisitions, or vouchers. They result from purely accounting transactions. However, the principle by which they are handled is the same in so far as costs are concerned.

In order to control indirect expense and account for it properly, some adequate, comprehensive classification of accounts is necessary. The scope and character of the various accounts should be clearly defined. Without such classification there is likely to be little uniformity and accuracy in making expense charges. Usually an account number

or symbol is assigned to each expense account. The expenses which come within the scope of the account are charged to the symbol for the account. The classification should be such that it lends itself to managerial control. As stated previously, it is desirable that the executives receive periodic reports of those expenditures which are within their control. Fig. 81 shows a shop-expense report. A copy of this report for a particular shop is sent to the foreman of that shop. Another copy goes to the head of the production organization. As will be seen, a mnemonic classification of expense accounts has been used.

**The Distribution of Indirect Expense.** In order to get total costs, the total indirect expense must be distributed over the various production orders by some method which will give the greatest accuracy of distribution, with regard to the factors in the particular situation under consideration which affect manufacturing and costs. The method which will give the best results in one plant may not be the best in another.

The intangible nature of a great many of the items which compose the indirect expense of manufacturing makes it practically impossible to devise any method of distributing such expense over production, that will be exactly accurate. For this reason, the simplest system that will give reasonable accuracy in cost finding is the most desirable. Costs are a tool for managerial control. Unless increased accuracy will pay for itself by savings from better control, usually it is not warranted. Beyond a certain point, the expense of operating the cost department increases more rapidly than the benefits from increased accuracy. It is easy to pass this point of diminishing returns without realizing it.

The indirect expense of manufacturing usually is one of the largest items in the cost of manufacturing. Therefore, the selection of proper methods of distributing this expense is an important problem. Most methods pro-rate indirect expense on the basis of the direct labor cost, direct material cost, the time required to complete the order, or a combination of these factors, because they can be collected for a given order with relative ease and accuracy. The following are some of the methods which have been used.

**Percentage on Direct Labor.** The distribution of indirect expense on the basis of its percentage relation to the direct labor cost of manufacturing is a method which is used in a great many plants. Usually the percentage of indirect expense to direct labor is determined from the actual results of the accounting period which has just closed. This percentage is applied to the direct labor costs of all orders processed during the succeeding period to get the proportionate share of the in-

direct expense that should be charged to each order. To make the method clear, it is assumed that for a given month—

| | |
|---|---|
| Total indirect expense has been | $125,000 |
| Total direct labor charges have been | 100,000 |
| Total direct material charges have been | 40,000 |
| Percentage of indirect expense to direct labor | 125% |

This percentage will be applied to the direct labor cost of all orders processed during the following months. Suppose that for a certain order—

| | |
|---|---|
| Direct material cost | $ 2.50 |
| Direct labor cost | 10.00 |
| Indirect expense charge @ | |
| Total cost of the order | $25.00 |

If the total indirect expense or direct labor charges are greater or less than the figures on which the percentage was based, the indirect expense for the month will be over-absorbed or under-absorbed. The difference between the amount absorbed and the actual indirect expense for the month must be charged off to some account for unabsorbed expense, and eventually to profit and loss, or the indirect expense charges to the various orders must be adjusted by means of a supplementary percentage.

If the books are closed monthly, it may be found that the percentage of total indirect expense to direct labor was 130 per cent. Inasmuch as the indirect expense was distributed on the basis of 125 per cent of direct labor, there will be a certain amount of the indirect expense which was not absorbed in production. Probably 130 per cent will be used as the basis of distribution for the next month. During periods of decreasing business the percentage will tend to increase continuously, and the cost of orders having the same prime cost will be greater in each succeeding period because the indirect expense of manufacturing does not fluctuate as widely as the prime cost, with fluctuations in the volume of production. Despite the fact that no more hours of labor, no more pounds of raw material, no greater use of equipment, or other factors which enter into production, are required to manufacture the product, its cost will appear to be greater. In a period when business is decreasing and prices are falling, the apparent trend of costs is opposite to the trend of prices. Costs cease to be of any great value in quoting prices, when computed by this method. Although expenditures for a large part of the indirect expense of manufacturing must be made whether we manufacture much or little, the failure to fill the plant with a normal volume of production is, to a large extent, the

fault of the management. The difference between the amount of indirect expense that is absorbed by production, using a normal percentage on direct labor, and the actual amount of indirect expense, is a charge that should be made against the management when the plant has less than a normal volume of production. It is more proper to charge it to some profit-and-loss account than to spread it over a diminished volume of production. A great many concerns that distribute indirect expense as a percentage of direct labor do not use a normal percentage, but the previous month's percentage as described. The effect is to average indirect expense over present production, giving a view of costs which in many respects is misleading.

There is a further objection to this method in that it takes no account of the variations in the costs of orders due to variations in the size and value of the equipment. Obviously, the order that requires a large expensive machine should bear a greater proportion of indirect expense than the order that requires only bench work. The machine requires greater floor space. Therefore the work done on it should bear a greater share of such charges as rent, light, heat, interest, depreciation of buildings and general equipment, and similar items. Undoubtedly the other items of indirect expense should be distributed over production in varying proportions depending on the value of the service required. If expense is distributed on the basis of a percentage on direct labor, ten dollars of direct labor expended at the machine will bear the same amount of indirect expense as ten dollars of direct labor expended at a bench.

In addition, no account is taken of the varying speed and skill of workmen. A first-class man might be paid one dollar per hour, and take one hour to complete the job. A poor man might be paid fifty cents per hour and take two hours to complete it. In both cases the labor cost is the same. However, in the first case the skilled workman used the production facilities only one-half as long as the poor workman did. Therefore the first job ought not to be charged with as much indirect expense as the second job. Using a percentage on direct labor, both jobs will be charged with the same amount.

This method is widely used because it involves less clerical expense than some of the others which will be discussed. In cases where the labor cost forms the greater part of the prime cost there are no great variations in the size and value of equipment used, or all products pass through approximately the same processes, and the volume of production does not fluctuate widely, it will distribute indirect expense with sufficient accuracy.

**Percentage on Direct Material.** In cases where a single product, or a few products, in which the direct material cost forms the greater part

of the prime cost, are manufactured, the indirect expense is sometimes distributed on the basis of a percentage of the direct material cost. Suppose that in a case of this kind the expenses for a given month are:

| | |
|---|---|
| Total indirect expense | $125,000 |
| Total direct labor charges | 40,000 |
| Total direct material charges | 100,000 |
| Percentage of indirect expense to direct material | 125% |

As in the previous case, this percentage will be applied to all orders processed during the following month. For a given order, the cost might be computed by this method as follows:

| | |
|---|---|
| Direct material cost | $10.00 |
| Direct labor cost | 2.50 |
| Indirect expense charge @ 125% of direct material charge | 12.50 |
| Total cost of the order | $25.00 |

The percentage on direct material cost is open to the same criticisms as the percentage on direct labor. The collected costs tend to increase as the volume of production decreases. No account is taken of the varying use of manufacturing facilities and services by different orders. No account is taken of the varying speed and skill of workmen, and the effect of differences in the time taken for the completion of orders. In fact, it is less sensitive in this respect than a percentage on direct labor and is virtually obsolete.

**Percentage on the Prime Cost.** The indirect expense may be distributed on the basis of a percentage of the prime cost of manufacturing. The principal advantage seems to be that it affords a broader basis of directly collected costs over which the indirect expense may be pro-rated. In addition, it may be somewhat more accurate in cases in which direct labor and direct material charges normally are approximately equal parts of the total manufacturing cost. Assuming for a given month that we have the same total prime cost of manufacturing as in the previous cases, costs would be computed by this method as follows:

| | |
|---|---|
| Total indirect expense | $125,000 |
| Total indirect labor charges | 70,000 |
| Total direct material charges | 70,000 |
| Prime cost | 140,000 |
| Percentage of indirect expense to prime cost | 90% |

This percentage will be applied to all orders processed during the following month. For an order having the same prime cost as in the previous cases, the cost would be:

| | |
|---|---|
| Direct material cost | $ 6.25 |
| Direct labor cost | 6.25 |
| Prime cost | $12.50 |
| Indirect expense charge @ 90% of prime cost | 11.25 |
| Total cost | $23.75 |

The percentage on prime cost is not generally used. It is open to most of the criticisms of the previous methods.

**Percentage of Man Hours.** One of the criticisms of the percentage of direct labor method is that it does not take sufficient account of the varying speed and skill of workmen, and the use that is made of production facilities and services. In order to give some opportunity for the influence of these factors to affect costs, indirect expense is sometimes distributed on the basis of a percentage of direct labor hours instead of direct labor cost. Assuming approximately the same expense data for a given month,

| | |
|---|---|
| Total indirect expense | $125,000 |
| Assuming 1,000 employees, classed as direct labor, and that the plant averages 25 days per month, working 8 hours per day. | |
| Direct labor hours for month | 200,000 |
| Indirect expense per direct labor hour | $0.625 |

This charge per hour for indirect expense will be made against the direct labor hours expended on each order processed during the following month. For illustrative purposes, it has been assumed that the plant worked 200,000 direct labor hours during the past month. Actually, the exact number of hours would be collected by the cost department.

If the prime cost of an order, processed during the following month is as shown below, its cost, computed by this method, will be:

| | |
|---|---|
| Direct material cost | $ 2.50 |
| Direct labor cost (20 hrs. @ $0.50 per hr.) | 10.00 |
| Indirect expense (20 hrs. @ $0.625 per hr.) | 12.50 |
| Total cost | $25.00 |

Indirect expense, to a large extent, is more closely related to time expended in producing the order than to direct labor or direct material costs. In cases where there are no great variations in the size and value of equipment, and the volume of production does not fluctuate widely, undoubtedly the percentage on direct labor hours will give a more reasonable distribution of indirect expense than any of the preceding methods.

In addition to relating costs more closely to the use that is made of production facilities and service, the distribution of indirect expense

is not affected by variations in wage rates. Two men may be performing the same class of work with the same skill and efficiency. If one man has been employed ten years and the other only six months, it is probable that the first man will have an hourly rate that is considerably higher than that of the second man. Under some systems of wage payment, this will affect the direct labor cost of identical jobs done under the same conditions. If a percentage on direct labor cost is used, the distribution of indirect expense will vary accordingly. If a percentage on direct labor hours is used, the distribution will not be affected by the difference in rates, because under the conditions assumed, the time to complete the job will be the same in either case. In cases in which there are considerable differences in skill, this method usually will bring out clearly the fact that the skilled man at a high rate is cheaper than the poor man at a relatively low rate.

In some cases, hourly expense rates are set up for each department. Where this is done, it is possible to charge the workmen's idle time to a department standing order for idle time, and to get the cost of such time in the various departments. Such information is often helpful in gauging the efficiency with which department heads manage.

**Machine Hour Rates.** The machine hour rate method of distributing indirect expense is intended to get a still more rational distribution. A great many items of indirect expense are more closely related to the size and cost of the machine than they are to any of the cost factors which have been discussed previously. Such items as rent, light, heat, and taxes, can be related to the number of square feet of floor space that are necessary for the efficient operation of the machine. The interest on the investment, the depreciation, maintenance cost, and similar items are greater for the large, expensive machine than they are for the small and relatively inexpensive machine. If some one wished to have part-time use of certain machinery or equipment, it would be necessary to determine the proper amounts in which the indirect expense should be allocated to the individual items of machinery and equipment in order that a fair and accurate hourly rental charge might be worked out for each item. If the equipment varies in size and cost, and is used to process work of a varying character, it is no less necessary that such rates be worked out because the company owns the equipment and operates it in its own interests.

The degree of refinement in which the machine hour rate method should be worked out depends to a large extent on the character of the business. The machinery and equipment may be classified roughly according to size or value, or an accurate, detailed analysis of indirect expense and its relation to the individual items of equipment may be made. In either case, the number of hours which each machine or

class of machine is expected to run during a given period, is determined. The expense allocated to each item or class of items is divided by the number of hours that it is expected to run to get the hourly charge that should be made against each order for the use of the particular equipment. In determining rates, all benches and work-places must be considered as equipment as well as machinery. If the number of hours run and the expense for the period are exactly the same as that on which the rate was based, the expense for the period will be entirely absorbed by production.

Suppose that in a given plant the equipment has been classified roughly according to its value. While in most cases such a classification would be too crude for actual use, it will serve to illustrate the method. The following items of expense are assumed, as in the preceding examples:

| | |
|---|---|
| Total indirect expense, preceding year | $125,000 |
| *Equipment* | 100,000 |
| Class A—10 machines valued @ $50,000 | |
| Class B—20 " " " 30,000 | |
| Class C—50 " " " 20,000 | |
| *Allocation of expense on the basis of the above valuations.* | |
| Class A | $ 62,500 |
| Class B | 37,500 |
| Class C | 25,000 |
| Total | $125,000 |
| *Hours run, assuming 2,400 hours per machine per year.* | |
| Class A (2,400 × 10) | 24,000 |
| Class B (2,400 × 20) | 48,000 |
| Class C (2,400 × 50) | 120,000 |
| *Machine hour rates.* | |
| Class A (62,500 ÷ 24,000) | $2.6401 per hr. |
| Class B (37,500 ÷ 48,000) | 0.7813 " " |
| Class C (25,000 ÷ 120,000) | 0.2083 " " |

On the basis of the prime cost and machine time, shown below, and using the above machine hour rates, the cost of the order would be computed as follows:

| | | |
|---|---|---|
| Direct material cost | | $ 2.50 |
| Direct labor cost | | 10.00 |
| Indirect expense | | |
| 3 hours —machine class A @ $2.6401 | $7.92 | |
| 4½ " " " B @ 0.7813 | 3.52 | |
| 5 " " " C @ 0.2083 | 1.04 | |
| | | 12.48 |
| Total cost | | $24.98 |

Even when some crude basis of allocating expense is used, such as that used in the above illustration, a considerable amount of detail work is required to make up rates for a number of types, kinds, and classes of equipment. Because of the expense involved, machine hour rates usually are not changed more often than semiannually or annually, even though the indirect expense for a given month may be over-absorbed or under-absorbed. In some cases, standard machine hour rates, based on what is considered a normal amount of business and indirect expense, are used. The advantage of standard rates is that costs are more comparable, and are better indices of managerial efficiency, inasmuch as it is possible to compare the actual absorption by production of indirect expense at the standard machine hour rate with the normal absorption.

Usually the indirect expense for a given month will be over-absorbed or under-absorbed. The difference between the actual indirect expense and the amount absorbed may be pro-rated over the orders processed during the month by means of a factor, based on the amount of indirect expense already distributed to them by means of the machine hour rates. The objection to this method is that it involves a considerable amount of additional clerical work in figuring costs. Furthermore, it produces the effect of apparently increasing or decreasing costs due to a decreasing or increasing volume of business. It is better to consider the amount of indirect expense that is over-absorbed or under-absorbed as a credit or charge against the management, corresponding to its ability to keep the plant filled with work and operating effectively. In accordance with this concept, the difference between the actual indirect expense and the amount absorbed would be charged to an account for over-absorbed or under-absorbed expense. The balance in this account, at the end of the year, or some other convenient period, would be charged to profit or loss.

The objection is sometimes raised that often it may be necessary to use larger and more expensive machines for an operation than are required, for the reason that the equipment that is normally used is filled up with work and is not available. As a result, more than the usual proportion of indirect expense will be charged against the order on which the particular operation is performed. Inasmuch as the operation actually is more expensive, it is better that the additional expense be reflected in the cost of the order. Otherwise, costs will not be an accurate index of manufacturing results.

The machine hour rate method is well adapted to an accurate accounting for idle machine time. For reasons that have been discussed previously, an accurate account of such time is a valuable aid in factory management.

**Expense Distribution by Production Centers.** The production center method of expense distribution developed by Mr. A. Hamilton Church is a refinement of the machine hour rate method.

Indirect expenses are collected as far as possible according to the particular departments that incur them. In some instances, a series of expense accounts is set up for each shop, to which its indirect operating expense is charged. Fig. 81 is an example of the form in which a report of this expense is rendered to the department head monthly. In addition, other indirect expense of manufacturing is analyzed to determine what items can be allocated directly to each department and what must be pro-rated to them. Depreciation and interest charges for machinery can be departmentized on the basis of the character and value of the machinery and equipment in each department. The power used in driving the machinery can be metered. However, there are many items that must be pro-rated. Interest, depreciation, and other expenses connected with land and buildings can be pro-rated over the different departments on the basis of their floor area. The expense of heating and lighting can be pro-rated on the same basis. An analysis must be made of the various items of general indirect expense to determine what is the best basis for pro-rating them over the various departments.

Within the department, the equipment is divided into a number of production centers. A production unit may be a single machine, a group of machines of the same class, a group of machines not of the same class but which are used to perform a specific process, or merely a work-place, such as a bench. Each production unit, with the floor space necessary for its operation, is called a production center.

Where possible, the indirect expense of the department is allocated directly to each production center. In the case of the interest and depreciation charges, to which reference has been made previously, the charges for the machinery and equipment in each production center can be made directly against the center. The department power charge can be pro-rated over the equipment on the basis of the rated horsepower of each machine. The general indirect expense charges which have been charged to the department can be pro-rated over the production centers on the basis of the floor space required by each center. When all of the indirect expenses have been broken down against the various production centers within the department, we have an annual charge against them which may be considered as a rent for the plant and organization services which they receive.

Assuming that the expense and the volume of production during the succeeding year will be approximately the same, the indirect ex-

pense should be absorbed by the orders processed during the year, in proportion to the use which they make of the various production centers. In order to get an hourly machine charge to be made against orders, the total expense charged against each center is divided by the total number of machine hours which each center should run during the year. If an order uses a given machine in a production center for two hours, it is charged for the use of the machine at the machine hour rate for the particular production center.

To give a simple illustration of the production center method, data will be assumed only for the indirect expense of taxes, insurance, light, and heat. While there are many other items of indirect expense which would ordinarily be included, their inclusion would merely complicate the illustration without clarifying the principle further.

PRODUCTION CENTER METHOD

| *Items* | *Annual charge* |
|---|---|
| Taxes | $10,000 |
| Insurance | 1,200 |
| Light | 2,400 |
| Heat | 5,000 |
| | $18,600 |

| *Departments* | *Net floor space* |
|---|---|
| Shop "A" | 2,000 sq. ft. |
| Shop "B" | 3,000 " " |
| Shop "C" | 5,000 " " |
| Total | 10,000 " " |

The pro-rata charge for these items, then, is $1.86 per square foot.

PRO-RATA SHARE OF EXPENSE

| *Departments* | *Pro-rata share* |
|---|---|
| Shop "A" @ $1.86 sq. ft. | $ 3,720 |
| Shop "B" " " " " | 5,580 |
| Shop "C" " " " " | 9,300 |
| Total expense | $18,600 |

FLOOR SPACE ASSIGNED TO PRODUCTION CENTERS

SHOP "A"

| *Production centers* | *Floor space* |
|---|---|
| Center No. 1 | 400 sq. ft. |
| Center No. 2 | 700 " " |
| Center No. 3 | 600 " " |
| Center No. 4 | 300 " " |
| Total floor space, Shop "A" | 2,000 " " |

PRO-RATA SHARE OF EXPENSE ASSIGNED TO EACH PRODUCTION CENTER

| *Production centers* | *Pro-rata exp.* |
|---|---|
| Center No. 1 | $ 744 |
| Center No. 2 | 1,302 |
| Center No. 3 | 1,116 |
| Center No. 4 | 558 |
| Total expense, Shop "A" | $3,720 |

If there were 10 machines in production center No. 1, and each machine were operated normally for 200 hours per month, there would be 24,000 machine hours available per year. Therefore, that part of the total machine hour rate for production center No. 1 that represents taxes, insurance, light, and heat, would be $0.031.

Assuming the following machine hour rates and cost data, the cost of an order would be computed by the production-center method as follows:

MACHINE HOUR RATES

| | |
|---|---|
| Production Center No. 1 | $0.78 |
| Production Center No. 2 | 0.63 |
| Production Center No. 3 | 1.17 |
| Production Center No. 4 | 1.36 |

COST OF ORDER

| | | |
|---|---|---|
| Material | | $ 2.50 |
| Labor | | 10.00 |
| Indirect expense | | |
| 4 hours, Production Center No. 1 @ $0.78 | $3.12 | |
| 5 hours, Production Center No. 2 @ 0.63 | 3.15 | |
| 4 hours, Production Center No. 3 @ 1.17 | 4.68 | |
| 3 hours, Production Center No. 4 @ 1.36 | 4.08 | 15.03 |
| Total cost | | $27.53 |

Fig. 129 shows the composition of the expense charged against a group of closely allied departments in a large munitions plant operating during the War. This expense was pro-rated against the production centers in these shops in the manner shown above. The machine hour rates are shown in Fig. 130.

As previously pointed out, it is seldom that the machine hours actually run will equal the machine hours available during any given period. In Fig. 129 a shop factor has been worked out by means of which the unabsorbed expense can be distributed over the orders processed during the month. Such distribution involves considerable work, and its propriety is doubtful. It is better to charge the over-absorbed or under-absorbed expense to some account for such expense, and eventually to profit and loss.[1]

[1] See page 431.

The routine of collecting costs by the production-center method involves more work than any of the preceding methods. When the operation tickets have been extended to get the labor cost of the order, they must again be extended to get the machine cost. The operation ticket shown in Fig. 40 has spaces at the bottom in which can be

MACHINE BURDEN ADJUSTMENT AND SHOP FACTOR FOR C. F. SHELL SHOPS—MAY, 1917

| | Total expense | Machine burden earned | Shop factor | Mach. hrs. avail. 48-hr.wk. | Machine hours run | Per cent machine activity |
|---|---|---|---|---|---|---|
| C. F. drawing........ | $ 27,151 | $18,010 | 1.5 | 36,800 | 22,694 | 61.6 |
| C. F. cut-off......... | 9,329 | 6,693 | 1.4 | 15,467 | 11,040 | 71.6 |
| C. F. heading........ | 29,559 | 10,610 | 2.8 | 19,360 | 10,056 | 52.0 |
| C. F. reducing........ | 13,948 | 4,882 | 2.9 | 10,452 | 4,084 | 39.1 |
| C. F. priming........ | 12,072 | 6,350 | 1.9 | 8,929 | 6,056 | 68.0 |
| C. F. trimming....... | 10,998 | 9,071 | 1.2 | 22,428 | 12,447 | 55.5 |
| C. F. s. inspection.... | 8,427 | 2,595 | 3.2 | 43,550 | 16,155 | 37.1 |
| C. F. gas anneal...... | 2,205 | 875 | 2.5 | 5,809 | 1,620 | 26.9 |
| Total........... | $113,689 | $59,086 | 1.9 | 162,795 | 84,152 | 51.6 |

EXPENSE DISTRIBUTION OF C. F. SHELL SHOPS FOR MAY, 1917

| | Control. exp. incl. pro-rata group office expense | Pro-rated aux. exp. includ. dept. office expense | Pro-rated general expense | Total expense |
|---|---|---|---|---|
| C. F. drawing............. | $12,603 | $ 6,705 | $ 7,843 | $ 27,151 |
| C. F. cut-off.............. | 5,044 | 1,911 | 2,374 | 9,329 |
| C. F. heading............. | 16,176 | 3,473 | 9,910 | 29,559 |
| C. F. reducing............. | 7,666 | 2,412 | 3,870 | 13,948 |
| C. F. priming............. | 7,565 | 1,740 | 2,767 | 12,072 |
| C. F. trimming............ | 5,691 | 1,927 | 3,380 | 10,998 |
| C. F. s. inspection......... | 3,870 | 1,720 | 2,837 | 8,427 |
| C. F. gas anneal........... | 1,108 | 437 | 660 | 2,205 |
| Total................. | $59,723 | $20,325 | $33,641 | $113,689 |
| Special Product............ | $ 1,044 | $ 418 | $ 974 | $ 2,436 |

FIG. 129

entered the machine hours, the machine hour rate, and the machine cost or indirect expense to be charged against the order. The machine cost is entered on the cost card for the order.

Furthermore, in order to account for the absorption of indirect expense, what amounts to a machine payroll must be kept. When the operation tickets have been sorted first according to employee's name

and number and then according to order number, for payroll and cost purposes, they are sorted according to department number and machine symbol. The machine hours run by each class of machine or production center in each department are posted to a machine hour record for the particular department. Figs. 131 and 132 show such a record. Each vertical column is used to record the hours run by each production center. The horizontal divisions are for each day of the month.

SUMMARY OF RELATIVE COST NUMBERS FOR MACHINES IN THE C. F. GROUP

| | *Relative cost numbers* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| B = C + D + E + F | Total | Total | Apportioned charges | | | | Total | |
| A = B + G<br>Use A and G on current reports and records. | rate | appor. charges | Fixed charges and bldg. rntl. | Auxil. expense other depts. | Auxil. exp. etge. dept. | Annl. and wash. | Direct controllable expense, inclg. grp. off. | No. of mchs. |
| *Machine Symbols* | *A* | *B* | *G* | *D* | *E* | *F* | *C* | |
| *Drawing* | | | | | | | | |
| PDD (each side)... | $ .78 | $ .73 | $ .05 | $ .07 | $ 04 | $ .18 | $ .44 | 30 |
| All other machs.... | .78 | .73 | .05 | .07 | .04 | .18 | .44 | 137 |
| *Cut-off* | | | | | | | | |
| All machines KCA. | .63 | .58 | .05 | .09 | .04 | .10 | .35 | 71 |
| *Heading* | | | | | | | | |
| PHH (horizontal).. | 1.17 | 1 07 | .10 | .09 | 07 | .07 | .84 | 62 |
| PHV (vertical).... | .87 | .83 | .04 | .07 | .07 | .06 | .63 | 24 |
| *Reduce* | | | | | | | | |
| 1PRA............ | 1.36 | 1.27 | .09 | 09 | .08 | .14 | .96 | |
| All other machines. | 1.14 | 1.06 | .08 | .08 | .07 | .13 | .78 | 41 |
| *Gas anneal* | | | | | | | | |
| All machines...... | .54 | .46 | .08 | .05 | .05 | | .36 | 27 |
| *Trim* | | | | | | | | |
| All machines...... | .75 | .68 | .07 | .04 | .02 | .05 | .57 | 100 |
| *Prime* | | | | | | | | |
| All machines...... | 1.05 | 1.00 | .05 | .08 | .08 | .14 | .70 | 41 |
| *Inspection* | | | | | | | | |
| Per operator hour.. | .45 | .39 | .06 | .02 | .07 | | .30 | |

FIG. 130

At the end of the month, the hours run by each center are totaled. This total, divided by the total hours available, gives the machine hour activity percentage for each center. The total hours run, multiplied by rate "A," gives the total indirect expense that has been absorbed. When multiplied by rate "B," the controllable expense that has been absorbed. The total indirect expense charged to the department for the month divided by the total indirect expense that has been absorbed, gives factor "A." The controllable expense for the month divided by the controllable expense that has been absorbed gives factor "B."

.................... SHOPS .................... DEPT. FROM .................... TO ....................

2140 1M 6-17 MACHINE TIME IN TENTHS OF HOURS

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No of M | | | | | | | | | | | | | | | |
| Machine Symbol | | | | | | | | | | | | | | | |
| Rate A | | | | | | | | | | | | | | | |
| Rate B | | | | | | | | | | | | | | | |
| 1 | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | | | | |
| F. W. D. | | | | | | | | | | | | | | | |

FIG. 131

A Machine-Hour Record—Front

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No of M | | | | | | | | | | | | | | | |
| Machine Symbol | | | | | | | | | | | | | | | |
| Rate A | | | | | | | | | | | | | | | |
| Rate B | | | | | | | | | | | | | | | |
| F. W. D. | | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | | | | |
| Total Hrs Run | | | | | | | | | | | | | | | |
| Total Hrs Available | | | | | | | | | | | | | | | |
| % Activity | | | | | | | | | | | | | | | |
| Total Burden Earned A×T | | | | | | | | | | | | | | | |
| Control Burden Earned B/T | | | | | | | | | | | | | | | |
| Factor A | | | | | | | | | | | | | | | |
| Factor B | | | | | | | | | | | | | | | |

FIG. 132

A Machine-Hour Record—Back

The controllable expense for the month is shown on the shop expense report.[1]

The advantages and disadvantages of the production-center method are similar to those of the conventional machine hour rate method and have been discussed previously. In cases where there is a wide variety of work and equipment, and the work is nonstandard or such that the products do not flow through the plant in sufficient volume for reasonably continuous production, it may often be used advantageously. The greater expense in collecting costs is offset by the greater accuracy in costing and the better control of manufacturing activities which is possible with more accurate and detailed cost and expense reports. However, for the majority of plants manufacturing a standard line of products, the production-center method may be too expensive to be justifiable.

**Closing Out the Order.** When the work on an order has been finally completed, some notice that the order has been closed out must be forwarded by the production department to the cost department. Upon receipt of such notice, the cost card for the order must be checked to see that all cost data have been received and recorded. The final cost of the order is then figured. The card is removed from the active file of cost cards.

**Summarizing Costs.** In order to judge the results for a given order and to follow the trend of costs, the final cost of the order may be entered on a comparative cost card. A card of this kind is shown in Fig. 133. The relation of the cost of the order to previous orders is immediately apparent. Periodically, the comparative cost cards on which important changes have taken place should be brought to the attention of the managing executive.

**Controlling Accounts.** In order to control the various direct and indirect expenses of manufacturing, the accounting system requires a large number of accounts. The various receipts and expenditures are classified. The accounts for those of a similar nature are grouped together in subsidiary ledgers which are summarized, by means of controlling accounts, in the general ledger. The final financial expression of the results of manufacturing activities is obtained in this ledger. Controlling accounts, then, are summary accounts into which the totals in the subsidiary ledgers are closed.

The cost cards are the plant work-in-process accounts. Periodicaly, the cost cards are totaled and the totals posted to work-in-process controlling accounts. There may be a number of such accounts representing various classes of product. Usually the postings are made monthly. Similarly, the cost cards which have been closed out during

[1] See Fig. 81.

the month are totaled, and the totals are charged to controlling accounts for finished stores, and credited to the controlling accounts for work in process. The production organization is relieved from further physical and financial responsibility for the product completed during the month.

It is possible to collect costs independently of the accounting system. However, it is the modern practice to tie the cost accounts into the general ledger because it affords a more unified control.

**Prospective Costs.** Prospective costs are intended to show in advance of manufacturing what the costs of the product should be. They are of two kinds—standard and predetermined.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOT NO. | | | | | | | | | | | | | | |
| QUANTITY | | | | | | | | | | | | | | |
| SCHEDULE | | | | | | | | | | | | | | |
| WRITTEN | | | | | | | | | | | | | | |
| ISSUED | | | | | | | | | | | | | | |
| STARTED | | | | | | | | | | | | | | |
| COMPLETED | | | | | | | | | | | | | | |
| QUAN COMPLETED | | | | | | | | | | | | | | |
| DATE PRICED | | | | | | | | | | | | | | |
| MATERIAL | | | | | | | | | | | | | | |
| LABOR | | | | | | | | | | | | | | |
| BURDEN | | | | | | | | | | | | | | |
| TOTAL COST | | | | | | | | | | | | | | |
| UNIT COST PER M | | | | | | | | | | | | | | |
| EST COST PER M | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |

3148A 3M 1-18 COMPARATIVE COST CARD

FIG. 133
A COMPARATIVE COST CARD

Standard costs are intended to represent a normal cost for the product. In some cases they are the average cost of the product over a period of time which is considered to be normal. In others, they are the result of a careful estimate of the cost of production under normal conditions. The labor costs may be determined from time studies of the various operations on the product. The material costs may be estimated from bills of material furnished by the engineering department. The indirect expense may be analyzed and its normal amount and relation to product costs determined. Standard costs are useful in determining the financial requirements for a coming period. They are valuable as a basis of comparison with actual costs. Indirect expense by departments, material and labor costs by classes of

product, and other cost items may be compared with standard costs for these items. With proper comparative cost reports, any variation from the standard is immediately brought to the attention of the management. Inasmuch as manufacturing conditions are continually changing, it may be necessary to revise the cost standards periodically to retain their comparative value. Obviously, standard costs are of greatest value when the product is standard and manufactured in large volume.

Predetermined costs forecast what the costs should be during a forthcoming period. They are scientific cost estimates based on time-study data, bills of material, studies of spoilage, indirect expense variation, and other cost data, modified by probable economic developments during the period under consideration. Inasmuch as they apply more specifically to a particular period, they are a more valuable basis for judging financial requirements, and the results that are being obtained. Predetermined costs may be derived from standard costs by applying percentages to them which will correct for increases or decreases in raw material and wage rates, and the effect of any changes in the volume of production on indirect expense.

**The Cost Accountant.** It will be seen from the preceding discussion that the cost accountant has a function which, if properly developed, is a valuable aid to both financial and production management. It is the financial inspection of production activities.

The cost accountant must have a thorough knowledge of accounting for the proper operation of his department and its coordination with the accounting department. In addition, he should be conversant with production problems and production methods. Otherwise the cost methods may not be developed to give the greatest possible aid to the factory management. In fact, a lack of such knowledge may result in costs which do not show a true picture of the situation.

In modern organizations, his position is one of importance and responsibility, requiring a valuable combination of qualities.

# BIBLIOGRAPHY

## *General*


ALFORD, L. P., Ed. Management's Handbook. The Ronald Press Co.—1925.

ATKINS, PAUL M. Factory Management. Prentice-Hall—1926.

BIGELOW, CARLE M. Installing Management in the Wood-working Industry. Engineering Magazine Co.—1920.

CARPENTER, CHARLES U. Profit-making in Shop and Factory Management. Engineering Magazine Co.—1908.

CHURCH, A. HAMILTON. Science and Practice of Management. Engineering Magazine Co.—1914.

COPLEY, F. B. Frederick W. Taylor. Harper & Bros.—1923.

DIEMER, HUGO. Factory Organization and Administration. McGraw-Hill—1925.

DRURY, H. B. Scientific Management. Columbia University Press—1918.

DUNCAN, J. C. The Principles of Industrial Management. D. Appleton & Co.—1911.

DUTTON, HENRY POST. Factory Management. Macmillan Co.—1924.

EIGELBERNER, J. The Investigation of Business Problems. A. W. Shaw Co.—1926.

EMERSON, HARRINGTON. Efficiency as a Basis for Operation and Wages. Engineering Magazine Co.—1919.

EMERSON, HARRINGTON. Twelve Principles of Efficiency. Engineering Magazine Co.—1912.

FAUROTE AND ARNOLD. Ford Methods and Ford Shops. Engineering Magazine Co.—1915.

FEDERATED ENGINEERING SOCIETIES. Waste in Industry. McGraw-Hill Book Co.

FLEMING AND BROCKLEHURST. Introduction to the Principles of Industrial Administration. Sir Isaac Pitman & Sons—1922.

GANTT, H. L. Industrial Leadership. Yale University Press—1916.

GANTT, H. L. Organizing for Work. Harcourt, Brace & Howe—1919.

GANTT, H. L. Work, Wages and Profits. Engineering Magazine Co.—1913.

GILBRETH, L. M. Psychology of Management. Sturgis & Walton Co.—1914.

GOING, CHARLES BUXTON. Principles of Industrial Engineering. McGraw-Hill—1911.

HISCOX, W. J. Factory Administration in Practice. Sir Isaac Pitman & Sons—1921.

HUNT, EDWARD EYRE. Scientific Management since Taylor. McGraw-Hill Book Co.—1924.

JONES, EDWARD D. The Administration of Industrial Enterprises. Longmans, Green & Co.—1925.

KIMBALL, DEXTER S. Principles of Industrial Organization. McGraw-Hill Book Co.—1925.

LANSBURGH, RICHARD H. Industrial Management. John Wiley & Sons—1923.

LAWSON, F. M. Industrial Control. Sir Isaac Pitman & Sons—1920.

LEE, JOHN. Industrial Organization. Sir Isaac Pitman & Sons—1923.

LEE, JOHN. Management. Sir Isaac Pitman & Sons—1921.

LIPSON, EPHRAIM. Increased Production. Oxford University Press—1921.

MARSHALL, L. C. Business Administration. University of Chicago Press—1921.

MASON, FRANK R. Business Principles, Organization and Efficiency. Lincoln Institute of Business—1921.

PARKHURST, FREDERICK A. Applied Methods of Scientific Management. John Wiley & Sons—1917.

POROSKY, MATTHEW. Practical Factory Administration. McGraw-Hill Book Co.—1923.

ROBINSON, WEBSTER R. Fundamentals of Business Organization. McGraw-Hill Book Co.—1925.

SCHELL, ERWIN HASKELL. Technique of Executive Control. McGraw-Hill Book Co.—1926.

SPOONER, HENRY JOHN. Wealth from Waste. G. Rutledge & Sons—1918.

TAYLOR, FREDERICK W. The Art of Cutting Metals. A. S. M. E. Transactions, Vol. 28--1907.

TAYLOR, FREDERICK W. Shop Management. Harper & Bros.—1919.

TAYLOR, FREDERICK W. The Principles of Scientific Management. Harper & Bros.—1911.

THOMPSON, C. BERTRAND. Scientific Management. Harvard University Press—1914.

VANDEVENTER, JOHN H. More Work per Man. Engineering Magazine Co.—1921.

VANDEVENTER, JOHN H. Planning Production for Profits. Engineering Magazine Co.—1921.

WALKER, P. F. Management Engineering. McGraw-Hill Book Co.—1924.

### *Material Control*

CARTMELL, MADISON. Stores and Material Control. Ronald Press Co.—1922.

FARQUHAR, HENRY H. Factory Storeskeeping. McGraw-Hill Book Co.—1922.

HUNT, WILLIAM F. Handling Material in Factories. Industrial Extension Institute—1920.

KILDUFF, FREDERICK W. Inventory Practice and Material Control. McGraw-Hill Book Co.—1925.

MITCHELL, WILLIAM NORMAN. Purchasing. Ronald Press Co.—1927.

RINDSFOOS, CHARLES S. Purchasing. McGraw-Hill Book Co.—1915.

TWYFORD, H. B. Purchasing. D. VanNostrand Co.—1924.

TWYFORD, H. B. Storing. D. VanNostrand Co.—1918.

### *Control of Operations*

ATKINS, PAUL M. Industrial Cost Accounting for Executives. McGraw-Hill Book Co.—1923.

BABCOCK, GEORGE. Taylor System in Franklin Management. Engineering Magazine Co.—1917.

BASSET, WILLIAM R., AND HEYWOOD, JOHNSON. Production Engineering and Cost Keeping for Machine Shops. McGraw-Hill Book Co.—1922.

CHURCH, A. HAMILTON. Production Factors in Cost Accounting and Works Management. Engineering Magazine Co.—1910.

CLARK, WALLACE. The Gantt Chart. Ronald Press Co.—1922.

FICKER, NICHOLAS THIEL. Shop Expense Analysis and Control. Engineering Magazine Co.—1917.

HARRISON, G. CHARTER. Cost Accounting to Aid Production. Engineering Magazine Co.—1921.

KNOEPPEL, CHARLES E. Graphic Production Control. Engineering Magazine Co.—1920.

LICHTNER, WILLIAM OTTO. Planned Control in Manufacturing. Ronald Press Co.—1924.

McKINSEY, JAMES OSCAR. Budgetary Control. Ronald Press Co.—1922.

RADFORD, GEORGE S. Control of Quality in Manufacturing. Ronald Press Co.—1922.

*Statistics*

BRINTON, WILLARD C. Graphic Methods for Presenting Facts. Engineering Magazine Co.—1914.

FARNHAM, DWIGHT T. Executive Statistical Control. Industrial Extension Institute—1918.

KENT, FREDERICK C. Elements of Statistics. McGraw-Hill Book Co.—1924.

MILLS, FREDERICK C. Statistical Methods Applied to Economics and Business. Henry Holt and Co.—1924.

SECRIST, HORACE. Statistics in Business. McGraw-Hill Book Co.—1920.

*The Factory Building*

CASE, WILLARD L. The Factory Buildings. Industrial Extension Institute—1919.

DAY, CHARLES. Industrial Plants. Engineering Magazine Co.—1911.

PRICE, GEORGE M. The Modern Factory. John Wiley and Sons—1914.

*Personnel Management*

ALLEN, CHARLES R. The Foreman and His Job. J. B. Lippincott Co.—1922.

BINGHAM, WALTER V. AND FREYD, MAX. Procedures in Employment Psychology. A. W. Shaw Co.—1926.

BLOOMFIELD, DANIEL. Labor Maintenance. Ronald Press Co.—1920.

BOETTIGER, L. A. Employee Welfare Work. The Ronald Press Co.—1923.

BRISSENDEN, PAUL F., AND FRANKEL, EMIL. Labor Turnover in Industry. Macmillan Co.—1922.

CHAPMAN, J. C. Trade Tests. Henry Holt and Co.—1921.

COLVIN, FRED H. Labor Turnover, Loyalty and Output. McGraw-Hill Book Co.—1919.

COMMONS, JOHN R. Industrial Goodwill. McGraw-Hill Book Co.—1919.

COMMONS, JOHN R. Industrial Government. Macmillan Co.—1921.

DIEMER, HUGO. Foremanship Training. McGraw-Hill Book Co.—1927.

FISH, E. H. Employment Management. Engineering Magazine Co.—1920.

GARDINER, GLENN L. Foremanship. A. W. Shaw Co.—1927.

HACKETT, JAMES D. Health Maintenance in Industry. A. W. Shaw Co.—1925.

HOOPINGARNER, DWIGHT L. Labor Relations in Industry. A. W. Shaw Co.—1925.

HULVERSON, GEORGE R. Personnel. Ronald Press Co.—1927.

KELLEY, ROY W. Hiring the Worker. Engineering Magazine Co.—1918.

KELLEY, ROY W. Training Industrial Workers. Ronald Press Co.—1920.

KNOWLES, MORRIS. Industrial Housing. McGraw-Hill Book Co.—1920.

LAIRD, DONALD A. Psychology of Selecting Men. McGraw-Hill Book Co.—1927.

LINK, HENRY C. Employment Psychology. The Macmillan Co.—1919.

MILLER, EARL J. Workmen's Representation in Industrial Government. University of Illinois Press—1924.

MORRIS, JOHN V. Employee Training. McGraw-Hill Book Co.—1921.

MYERS, JAMES. Representative Government in Industry. George H. Doran Co.—1924.

NATIONAL INDUSTRIAL CONFERENCE BOARD. Experience with Works Councils in the United States. The Century Co.—1922.

SCOTT, WALTER DILL, AND CLOTHIER, ROBERT C. Personnel Management. A. W. Shaw Co.—1926.
SHEFFERMAN, NATHAN W. Employment Methods. Ronald Press Co.—1920.
SIMONS, A. M. Personnel Relations in Industry. Ronald Press Co.—1921.
SLICHTER, SUMNER H. The Turnover of Factory Labor. D. Appleton and Co.—1919.
TEAD, ORDWAY, AND METCALF, HENRY C. Personnel Administration. McGraw-Hill Book Co.—1926.
TIPPER, HARRY. Human Factors in Industry. Ronald Press Co.—1922.
WEAKLY, FRANK E. Applied Personnel Procedure. McGraw-Hill Book Co.—1923.

*Office Management*

GALLOWAY, LEE. Office Management. Alexander Hamilton Institute—1918.
LEFFINGWELL, WILLIAM H. Office Appliance Manual. A. W. Shaw Co.—1926.
LEFFINGWELL, WILLIAM H. Office Management. A. W. Shaw Co.—1927.
MCCLELLAND, FRANK C. Office Training and Standards. A. W. Shaw Co.—1919.
MACDONALD, JOHN H. Office Management. Prentice-Hall—1927.
SCHULZE, JOHN W. Office Administration. McGraw-Hill Book Co.—1919.
WEAVER, AMY. Office Organization and Practice.

*Time and Motion Study*

GILBRETH, FRANK B. Applied Motion Study. Macmillan Co.—1919.
GILBRETH, F. B. AND L. M. Fatigue Study. Macmillan Co.—1919.
LICHTNER, W. O. Time Study and Job Analysis. Ronald Press Co.—1921.
LOWRY, MAYNARD AND STEGEMERTEN. Time and Motion Studies. McGraw-Hill Book Co.—1927.
MERRICK, DWIGHT V. Time Studies as a Basis for Rate Setting. Engineering Magazine Co.—1919.

# INDEX

THE HOUSE OF HARPER

NEW YORK

Publishers of BOOKS and of

HARPER'S MAGAZINE

*Established 1817*